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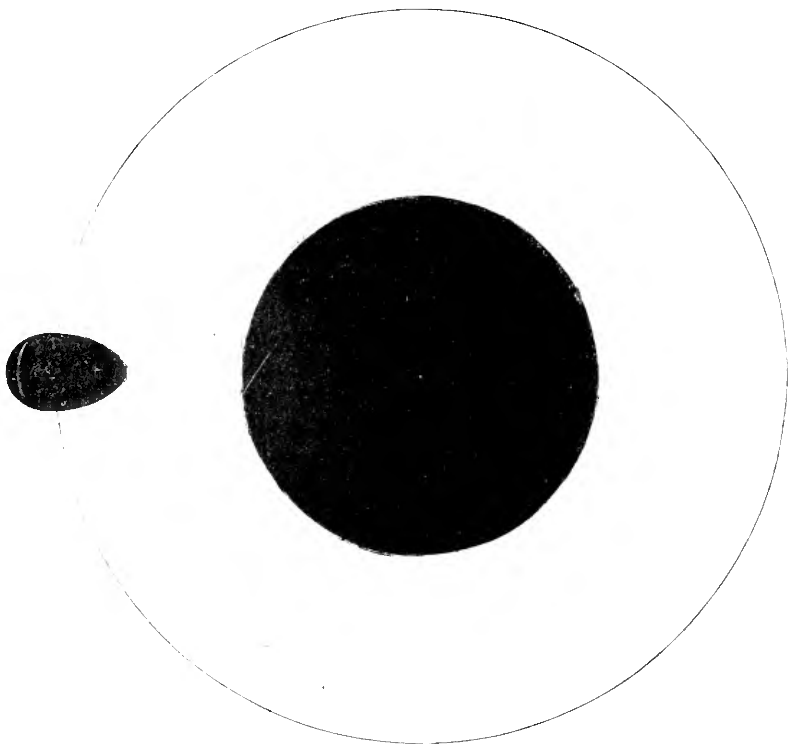
THE ORIGIN OF WORLDS.

By Professor DANIEL VAUGHAN.

IT is from the order of succession in Nature, and not from the everlasting endurance of her works, that we may reasonably expect the reign of perpetual activity in her wide domains. In the animal and the vegetable kingdoms the ravages of decay and death are eternally repaired by the birth of new representatives of life; and the loss which our continents undergo by occasional submergence is compensated by the appearance of new lands above the waters. Even those stupendous catastrophes involving planetary fate do not make an irreparable loss in the vast array of celestial objects. The matter saved from such mighty wrecks will again be available for useful ends; the forces which seem destroyed in the terrific convulsions only assume other forms to participate in new movements and operations, and even the space-pervading medium, while dooming the present worlds to an end in the distant future, yet contributes much to bring others into being, and to perpetuate the events and the wonders of our universe. A clew to the manner in which such important purposes are achieved is to be found on tracing the fate of planets or of satellites introduced into orbits of the smallest size possible; and these inquiries can be conducted with the aid of mathematical principles which are almost wholly unavailable in pursuing the details of the nebular hypothesis.

In treating on the equilibrium figure of the earth supposed to be a homogeneous fluid, Laplace has been much embarrassed on finding that, if the rotation were so rapid as to reduce the length of the day to two hours and twenty-five minutes, stability would cease to be possible, though the equatorial gravity would be only partially neutralized by centrifugal force. In solving analogous problems respecting the form of satellites confined to very small orbits and distorted from a spherical

shape, not only by diurnal motion, but by the more potent influence arising from the attraction of a great central orb, similar results may be obtained, but they admit of a more obvious explanation. The accompanying figure will give an idea of the manner in which, in such dangerous ground, a secondary planet would be affected, especially if it were composed of homogeneous and very yielding materials. If the two bodies were as disproportionate in size as Jupiter and his nearest moon, stability would be impossible on the minor one as soon as gravity



at the extremities of its longest diameter was reduced more than fifty per cent. by the disturbances. Of the fatal effects of a further reduction adequate proofs are afforded by three different modes of investigation which I have given in the "Philosophical Magazine" for 1860, 1861, and 1871. Accordingly, on coming into fatal proximity with its primary, such a satellite would not lose its matter in small portions, but would pass away in one great convulsion which would destroy the planetary condition and give birth to a ring.

The insecurity which analysis shows in this case in the mundane structure arises from the circumstance that, when gravity is reduced to less than one half its value along the greatest axis, the pressure along that line can no longer be made to counterpoise the pressure from other

directions. This rule will evidently need but slight modifications, when, instead of being so extremely unequal, both bodies have the same relation of size as that subsisting between our earth and moon, or even such as is represented in our diagram. In this case, however, the lesser body would bear a somewhat greater disturbing influence; but its dismemberment, though of a paroxysmal and a very extensive character, would be confined to the side next the primary. On losing a large portion of its mass, the satellite would swing into a wider orbit ; its distance from the primary would for a long period be increased by tidal action, and many ages must elapse before they again became near enough to give occasion for a like convulsive rupture. The incorporation of a large celestial body with a greater one around which it previously revolved would thus be effected by a number of paroxysms, and would not be completed before many billions of years.

The intermittent character of these rare events would be very decided, except, perhaps, when the subordinate body were, like a comet, composed of a profusion of exceedingly rarefied gas surrounding a small, dense, central nucleus. Such differences of density as may be naturally expected in the internal and superficial matter of a satellite would tend to give the convulsive dismemberment a somewhat reduced scale, and to make it recur after less remote periods of time. But this influence would be more than counterbalanced if the incorporating body were solid, as the planetary structure would be preserved for a longer time; but, when the rupture took place, the ruin would be more extensive. Indeed, in the cases most likely to occur, the doomed planet would meet its fate in successive stages, of which the number and magnitude may be estimated with tolerable accuracy. If our moon were made to revolve about 4,500 miles beyond our atmosphere, its coalescence with our globe would be inevitable, and it would take place by about six or eight paroxysmal stages extending over a vast immensity of time. Two or three times the number of such terrific convulsions may be expected in the union between Algol and the large planet which causes his variability ; and the same estimate will serve for the binary systems or the physically double stars when after long ages they become close enough for the incorporation of the less with the greater.

It is the terrific conflict of matter on such rare and stupendous events, that awakens the power which is mainly concerned in giving birth to worlds. Large primary planets would be called into being if one or both of the celestial objects undergoing these violent stages of combination had the rank of a sun. The vast mass of matter precipitated to the greater body on these occasions would sweep along its equator with furious velocity. But on the subordinate one, especially in its equatorial regions, the more superficial parts would slide over the internal nucleus in an opposite direction, in consequence of the tidal action, which in the new orbit must be powerful enough to produce not merely waves, but even progressive movements at the rate of many

leagues a second. From well-established principles and from facts made known by recent experimental researches of Edlund and Zollner, it is evident that immense currents of electricity would circulate around each mighty orb, but in different directions. On the most stupendous scale the two suns, or the sun and its great planetary attendant, would thus acquire magnetism, but have opposite polarities; and, in moving around their common center of gravity, they would exert over a wide domain the peculiar phenomenon which is but feebly manifested by a rotating horseshoe magnet.

Though the calorific effects of the encounters of great spheres have monopolized the attention of modern scientists, many facts show that mechanical action of the most extreme violence is attended with a larger conversion of energy into electricity and magnetism, and that in the case under consideration these forces must be developed on a more gigantic scale than heat and light. On the fall of a meteorite to the sun after a long course through his atmosphere on November 1, 1859, a disturbance occurred in terrestrial magnetism so quick and remarkable as to excite much attention at several stations of Europe and America. Even this circumstance alone would give grounds for a very high estimate of the magnetic agency called into being, if an amount of matter more than a thousand times that contained in our globe were hurled almost horizontally over a solar surface with a velocity of two or three hundred miles a second.

The consequences of the movements of the two great bodies, with the new properties which they assume in these convulsive stages, may be accurately traced by the aid of scientific principles for which Arago furnished a basis in 1825. Observing that, in the neighborhood of copper, water, glass, and other substances, a magnetic needle had its oscillations curtailed in the same manner as if it encountered the resistance of a medium, he endeavored to unravel the mystery by additional experiments, and was finally led to the discovery of magnetism of rotation. The researches which he commenced were continued successfully by Babbage, by Sir John Herschel, and others; it was found that a horseshoe magnet rotating around its axis would impart its circular motion to disks of copper with which it had no connection; but the inquiry was carried still further by Faraday, who proved all the effects on the electrical development attending the movement. Reasoning from what is known of such kinds of action, it is evident that the rapid revolution of the two great magnetized orbs could not sensibly affect the motion of preëxisting planets nor even of asteroids in the solar system; but it would alter much the courses and velocities of meteorites and meteoric dust; and it would be likely to make its influence felt in whirling the nebulous matter supplied by comets or separated from the equator of the greater central sun. At that theatre of violence, the matter would be dissociated perhaps into the sub-elements of Lockyer, and it would be quickly spread around, along the equatorial plane; so

that the electro-magnetic power would be favored with a good conductor for extending its control to great distances, and its effects can be traced without having recourse to any unwarranted assumptions respecting the passage of electricity through an absolute vacuum or through interstellar space.

The operation of such an agency in the heavens is shown by researches of a different character. M. Gaston Plante, of Paris, has been led by experimental evidence alone to ascribe the form of the spiral nebulæ to electro-magnetic action ; as their peculiar features correspond exactly to that which he produced by powerful electric currents under the controlling influence of a magnet. But the influence of the same forces is strongly impressed on the form of another class of nebulous objects. By investigations similar to those of Laplace in regard to the possible extent of the solar atmosphere, it may be proved that a rare gas surrounding a dense nucleus and with a uniform rotation could not be compressed in a greater degree than to show a thickness two thirds of its equatorial dimensions. Yet in many nebulæ with a central condensation the greater diameter is more than four times the less, and this would seem to indicate the operation of some force like dynamic electricity acting along the plane of the equator of these rarefied objects. The evidence on this point will seem stronger when we recollect that observation gives only an inadequate picture of the effects of this cause; as, in consequence of the position in which they are viewed, planetary nebulæ scarcely ever exhibit the full amount of their ellipticity or compression.

Other facts assist in revealing the nature of the forces at work in these celestial curiosities. Judging from peculiarities they present in the spectroscope, Lockyer and Frankland have concluded that several of the nebulæ must possess an exceedingly low temperature. Yet it is difficult to conceive that such cold, rarefied masses could be self-luminous, or that they could be visible to us even when surrounding a central sun, for gases have but a very feeble power of reflecting light. The difficulty, however, may be removed by supposing that the visibility of these nebulæ depends on the passage through them of electricity developed in some dark or bright binary system on the incorporation of the lesser with the greater orb. In this way an explanation may be found for the mysterious and unaccountable variations in the brightness of these objects. From the careful observations of Hind, D'Arrest, and other astronomers, it has been shown that, in a few cases, nebulæ have declined in light so as to become invisible, but reappeared after a time; thus exhibiting changes equally fatal to the ideas that they are congregations of stars or collections of fire-mist gradually cooling and condensing into planetary systems. But the mystery will be removed when we regard their light as dependent on the electro-magnetic action already described; for in its latter stages, especially when the tides on the smaller member of the binary were drawing to a close, there would be

occasional interruptions in the production of electricity and in its passage into space.

In ascribing to meteors an important part in the train of events which these widely extended forces are capable of producing, it is not necessary to adopt the extravagant estimates which were made of the numbers of these vagrant bodies in order to support a recently exploded theory in regard to the origin of celestial light. According to some eminent scientists, the amount of meteoric matter which falls to the sun's surface every year would increase his diameter annually about two hundred and forty feet, and it would exceed the mass of Mars. But from their occasional falls to the earth, and from other facts, it may be safely concluded that the number of meteors which become tenants of the solar dominions in the course of one or two millions of years, would afford material enough to form a planet as large as the earth, even if half their numbers could be made to unite into one body, instead of being allowed to rove indiscriminately through the system and to fall to the larger spheres. Now, the arrangement necessary for such a union would arise in our supposed binary system from the movement of the two suns in their magnetized condition around their common center of gravity. The powerful display of electro-magnetism succeeding each stage of dismemberment would gradually bring the majority of all the wandering meteors into the same plane, and give them orbits of a larger size and constantly approaching nearer to a circular form. Though constantly declining, this force must, during many thousand centuries, exert a predominant sway over meteors and comets, collecting them on the verge of the binary system in such numbers and in such a regular array that their aggregation into one body, though long deferred, would be inevitable. A nucleus once formed would increase by appropriating matter from the zone which it traversed, and, though at first much retarded in its growth, it would after many thousand revolutions attain a planetary size. Being largely composed of gaseous matter and therefore very sensitive to the resistance of a space-pervading medium, the newly formed planet would contract its large orbit; and room would be thus made for bringing into being another mundane structure when, after the lapse of millions of centuries, another paroxysmal stage of incorporation awakened electric energy and prepared the way for a new coalition of the vagrant matter of the celestial regions. After numberless ages the recurrence of the dismemberment would give existence to another planetary orb, and increase the mass of the preëxisting ones. Accordingly, the verge of a solar system must be considered as the birthplace of all its primary worlds.

It is evidently in this external zone, where solar attraction is most feeble, that we may hope to find the most favorable conditions for the union of small into large masses. In the asteroidal region two spheres of granite, having each a diameter of one hundred miles, could not control the velocity with which they would sweep by one another on meet-

ing if the planes in which they moved differed one degree in their inclinations to the ecliptic. A slight difference in the size or in the shape of their orbits would also be an unsurmountable barrier to their union. If a collision should occur between two asteroids, they would be only shattered into fragments, and a coalescence into one mass would be rendered more hopeless. But on the extreme verge of a solar system the numerous meteors consigned to large circular orbits lying in the same plane would have very nearly the same velocity in contiguous zones, and would be ready for the work of aggregation when their numbers were sufficiently increased by a long-continued electro-magnetic action.

In such an innumerable group of small and light bodies in symmetrical array, a large meteorite or the nucleus of a comet might become the embryo of a future world which may require many thousand years to attain the mass of one of the average asteroids. But its attraction after a time must become powerful enough to clear a large tract of space of matter, and thus to divide into two zones the great ultra-planetary ring of floating matter, while it must gradually make the paths of the small bodies deviate from true circles. From the outer zone it receives the meteors, which are in the perihelia of their orbits, and have their velocity most rapid; but the meteoric bodies from the internal zone unite with the growing mass near the points at which their motion is reduced to the lowest rate. Accordingly, the rotation of the new world must be in the same direction in which the constituents of the great ring were moving, and in which the parent orbs moved around their common center of gravity. The same direction of motion would also be exhibited by meteors which, instead of incorporating at once with the growing world, only described ellipses around it in accordance with the law of gravity.

In this early stage of its existence a world would be able to acquire a large train of meteors revolving permanently around it chiefly in consequence of two circumstances: The rapid increase in the mass and the attraction of the growing planet will make the velocity gained by bodies in approaching it always less than that lost while they are retiring; and orbits, even when slightly hyperbolic, would be changed into ellipses. Besides this, the vast atmosphere of nebulous matter around the new-born sphere would be more effective for the same end, as it would check the velocity of the passing meteors and cause them to revolve around the growing mass long before they incorporate with it. It is in consequence of these meteoric falls, and not the mere process of cooling, that the abundance of cometary and nebulous matter surrounding a young world is brought into a more dense condition. A planetary atmosphere of oxygen and hydrogen would maintain a gaseous form in spite of the refrigerating influence of many ages; but it would be quickly converted into aqueous vapor by the chemical forces awakened on the fall of a meteoric stone, and in the course of time might become liquid or solid as it parted with heat.

If in the immense annular group of bodies two centers of aggregation formed the two incipient worlds, ever increasing, their attractive power would be likely to form a binary system, both moving around the common center of gravity between them. It is when their conjunction takes place near the point where their orbits come nearest together that such a change may be expected. The inner planet having, then, its minimum and the outer its maximum velocity, the movement in the new binary system would be in the same direction as the common orbital motion around the central suns. To such a course of events may be ascribed the origin of the earth and moon, as well as the connection which exists between them; for even tidal action would be sufficient to reduce the eccentricity of the lunar orbit to its present state. If at that early period meteoric and cometary matter were so abundant that both orbs could become twenty times as large and massive, their distance apart would be so much reduced that the moon would long since have incorporated with our globe by a series of paroxysms which would arouse electro-magnetic forces into action and give birth to a family of satellites.

When, however, two embryonic planets, in the contiguous zones of the great ring of meteors, formed a binary system long before attaining their full size, their union would take place like that of greater masses, and be attended with like consequences. It is reasonable to suppose that, in the early stage of its existence on the verge of the solar system, Mars, like our earth, received a companion having about one or two per cent. of his mass, but confined to a small orbit. This primitive attendant, which was probably over one thousand miles in diameter, subsequently united with Mars by a series of convulsive stages; and, by awakening electric agencies, gave birth to a family of satellites of which Deimos and Phobos alone remain. The career of Jupiter and Saturn was characterized by the same train of changes and events. When they first sprang into existence, in the outer zone of our system, each of these great planets was attended with a large companion which subsequently incorporated with the superior orb by a series of paroxysms, and thus occasioned the birth of a family of minor worlds. Accordingly, in a system of classification based on their modes of origin, neither our moon nor perhaps that of Neptune could be assigned to the same class which includes the satellites of Mars, Jupiter, Saturn, and Uranus.

The very great disproportion between the world-forming power in great and in small binary systems, will appear in a clearer light by considering the violence in both cases attending precipitation from the less to the greater orb. Were our moon placed so near us that it must yield to the rupturing forces, each paroxysmal dismemberment would give to the earth a ring of lunar matter having a transverse section of 30,000 square miles, and forcing its way through the outer terrestrial structure with a velocity of five miles a second. But if the linear dimensions of

both bodies were ten times as great, the conflict of the invading mass would be about 100,000 times as violent, and a correspondingly greater amount of energy would be converted into electric, magnetic, and calorific forces. Accordingly, great suns, in passing through their most terrific scenes, call forth a world-making power of the greatest vigor; and will not only give birth to larger spheres, but also send them forth in wider orbits.

But the size and mass which a world attains must depend mainly on the numbers of meteors and comets frequenting the solar dominions while it was in the course of formation. At the birth of Jupiter this vagrant matter was more than usually abundant, and it served to give the planet a predominance over the other members of the solar family. It is very probable that the minute and the rare tenants of space are very numerous in the Milky Way; but this abundance of chaotic material, though calculated to increase the size of worlds, must shorten their term of existence, as the increase which suns obtain in mass and attraction would have the same effect as a resisting medium in abridging the lives of their planets. Events involving the mortality of worlds would thus become more frequent; and it is worthy of remark that it was in or near this part of our universe that most of the temporary stars have sent forth their sudden display of brilliancy. In such a region a planet of large size in closing its career by incorporating with a sun would be attended by an electro-magnetic energy sufficient to give birth to another planetary member of considerable magnitude on the outer zone of the solar system, so that the existence of worlds would not be wholly dependent on the union of double suns.

But even in our own part of the celestial domain there are to be found evident marks of the occurrence of one of those stupendous events to which I have ascribed the appearance of temporary stars, and which are so intimately connected with the birth and death of worlds. On comparing the observations of Carrington and Spoerer with those of Vogel and Young, it appears that for the sun's equatorial zone the time of rotation is scarcely twenty-two days, while it is nearly four weeks for the parallel of fifty degrees. So great and unexpected a difference in the diurnal motion of its parts proves that our central luminary must have at some past time received a large mass, which had a direct motion over his equator, and was finally precipitated to his surface. Whether the incorporating mass was a planet, or the last remains of the great companion which coöperated in giving being to the solar family, the effects deserve attention so far as they show the present working of a power which has been long in a declining condition. The movement of one zone of matter over another having a different velocity of rotation must be a source of solar magnetism, and this force may be therefore regarded as much weaker than it was a million years ago, but much stronger than it will be in very distant future ages.

Yet, even in its reduced state, this magnetic agency is not without

control through a wide range of space. If the loss of meteors which become a prey to the attraction of great spheres be replenished by the entrance of new ones into our system, the new visitants from ultra-planetary space would, in consequence of a resisting medium, be found in the greatest numbers along the line of the sun's progressive motion. The arrangement seems, however, to be modified by the sun's magnetism, which, by favoring direct motion in the plane of his equator, gradually leads to the meteoric array which is manifested in the appearance of the zodiacal light. That this light is reflected by innumerable meteors, is an opinion which has long been maintained, and which has been confirmed by late observation; but it is only from the physical consideration which I have presented, that we can account for the permanence of a phenomenon depending on the presence of objects of so minute and perishable a character. To the same cause may be ascribed the direct motion of the comets of short periods of revolution. These effects will give some idea of what might be accomplished by solar magnetism when, as in the cases I have considered, it becomes many million times more powerful than that of our sun, and when it is favored with all the conditions for arranging chaotic matter for a transformation into worlds.

THE GROWTH OF THE WILL.

By ALEXANDER BAIN,
PROFESSOR OF LOGIC IN THE UNIVERSITY OF ABERDEEN.

I DESIRE to offer a few observations in reply to the paper by Professor Payton Spence, in the August number of the "Popular Science Monthly,"* on my theory of the growth of the Will.

By a calculation of the chance coincidences of the muscles of the human body, Professor Spence appears to reduce to an utter absurdity any theory that makes the will depend upon trial and error. At the same time, he finds in the doctrine of evolution an easy way out of the difficulty.

1. My first remark is, that I from the first assumed a large number of instinctive connections among our organs, not perhaps so large a number as may now seem requisite, but still so many as to reduce greatly the random tentatives in new acquisitions. In my chapter on instinct ("The Senses and the Intellect," and mental science) I described under reflex actions and primitive combined movements, numerous instinctive groupings of considerable complexity on which the will can build its subsequent powers. I set no limit to the number of such instincts; only, I did not refer to any that were not more or less immediately apparent. I reasoned out the locomotive rhythm in the human

* "Voluntary Motion," by Prof. Payton Spence, M. D.

subject, notwithstanding that it can not be manifested at birth, as in the case of quadrupeds.

2. When I composed "The Senses and the Intellect," the doctrine of evolution was not before the world in any shape. I made no attempt to frame an hypothesis to account for our instincts; I assumed them as I found them, and described the progress of the individual acquisitions as they appeared to my observation. In my subsequent writings I have made ample use of the hypothesis, so far as I think it agrees with the facts. I may refer more particularly to the third edition of "The Emotions and the Will," published not long ago. In "Mental and Moral Science" I allow for the probability of hereditary acquisitions in reference to the various relations summed up in the knowledge of space.

3. My theory of the will, as first conceived, was the expression of the facts as I was able to view them at the time. I regarded as acquisitions everything that appeared to need teaching in some shape or other; as, for example, speech. I inquired what were the powers that existed in the absence of teaching, and what were those that came into being only by teaching, or by some sort of experience or acquirement. I may have misconceived the scope of the two departments; but, to the best of my knowledge at the time, I endeavored to appreciate the extent of each. I saw that an infant at the end of a few months could perform simple articulations, as *wa*, *na*, *bo*, *bu*, and that on these could be based the instruction in speech. I did not consider that the articulations could be taught; I was inclined to believe that they might be stumbled on by random tentatives. I now proceed to remark on Professor Spence's *reductio ad absurdum* of that operation.

4. When the Professor talks of the number of muscles that must come into play in pronouncing the letter A, and of the enormous unlikelihood of a child stumbling on the right one in a few months, he leaves out of account various circumstances. For one thing, the combinations are absolutely limited by mutual conflict; only such groupings as can go together are to be allowed. How far this would reduce the possible number of trials I do not say, nor do I mean to affirm that the number would not remain very large; still his figure would be very seriously reduced. I will take a more patent example than speech, namely, the movement of the eyes. We know that six muscles are at work; and, allowing several gradations of energy to each, say four, there are twenty-four elements to play upon in every variety of combination. But now, instead of summing the arithmetical possibilities of union among these elements, let us survey the outcome. Of course in many of the combinations, as when two opposing muscles were equally stimulated, there would be no result; there would be simply a shock of painful collision. When the stimuli are unequal, there would be motion in some one course—up, down, right, left, slanting, curved. The possibilities now are not so very formidable: the eye can only

sweep over its field of vision to and fro, here and there; its movements might conceivably be very numerous, but all the purposes of voluntary acquirement might be served without a very great number.

Because the muscles admit of all these possible stimuli, it does not follow that the brain will ever impart them all. The limits of the motor centers would be the limits of the spontaneous impulses. The workings of the system are brought within a narrow routine, from the deficiency of the nervous matter. There are possibilities of combination of the muscles of the eyes that may never have been realized by the educated eye, far less by the uneducated eye.

Take, again, the swing of the limbs. Many muscles are at work, and many possibilities of union are open; but how few are actually realized! The supposition of the vastness of the possible combinations cuts two ways: it opens up an almost infinite source of active capability. For, although it might be long ere we reached some one particular combination, yet, out of the number of combinations that we might make, we should fall upon manifold obvious utilities that would be soon confirmed into useful habits. The same end may be served by many varieties of means; there might be fifty thousand routes of the hand to the mouth, but, provided it got there anyhow, all would end well. The observation would apply generally to Professor Spence's millions of possibilities: many thousands of them would equally hit the same mark.

5. I might dwell at greater length on the two limiting considerations now adduced; that is to say (1), the limits of the central mechanism, and (2) the equal suitability of many thousands of the supposed possible combinations to given ends. I go on, however, to cite the most important qualification of all—the self-controlling power of the active mechanism. This is the assumption needed to account for the origin of voluntary power, whether in the individual or in the race. To expatiate upon this would only be to repeat what I have said in my writings; and I could not, in a short space, say anything that would be likely to satisfy Professor Spence. I prefer for what remains of my paper to comment upon his own theory, namely, the doctrine of heredity or evolution, which he puts forward as the true solution of the difficulties of the will. In the first place, however, I refer him to "The Emotions and the Will," third edition, p. 318, where I endeavor to show that the postulates of my theory of will—namely, spontaneity, the law connecting pleasure with increased vitality, and the contiguous growth of accidental connections—are indispensable to the evolution doctrine, as stated by Spencer and Darwin. What I mean now to affirm is, that precisely the same difficulty, arising from millions of possibilities of combined action, occurs at every step of our progress by evolution. The only thing that serves to abate the difficulty is that, when a happy combination is once struck, it is hereditarily transmitted and becomes a possession for ever. This would be an important mitigation, if hereditary transmission were easily and soon effected; but the facts show

clearly that a vast space of time is required to bring any acquisition up to the point of being transmitted to a perceptible amount. So that the time obstacle still recurs; and Professor Spence's difficulty of permutations and combinations recurs with it. Indeed, if his computations were good as against my view of the will, it would be little less crushing against the start of voluntary power in the race: we should need to substitute, in order to the development of humanity, for millions of years, millions of millions. It is evident, to me at least, that there must be a shorter road, in both cases, than his calculations would suppose.

6. I am quite ready to grant that our voluntary acquisitions repose upon certain established tendencies—call them instinctive or hereditary—and that the Professor is perfectly correct in describing the mature will as a mixture of organic maturation with proper acquisition. But I should not quite concur in his mode of expressing the proportions of the two. I think I could show that the brain of man, while it must contain at birth many preëstablished groupings or connections, is distinguished for its flexibility, adaptation, or educability; and that, if we were to sum up the contents of any of our leading acquisitions, say speech, the primordial part—the supposed capacity of articulation—which the Professor thinks would need millions of tentatives, is the base for a superstructure of enormous extent, needing nothing to account for it but the power of retentiveness operating upon these few articulate modes. Consider the power of speaking seven languages, and how little of this can be by any possibility transmitted, and we must admit that, somehow or other, a vast number of connections can be established in the lifetime of an individual; every reasonable allowance being made for hereditary tendencies.

7. In order to prove that we possess by hereditary transmission a countless number of organized muscular arrangements, upon which our acquisitions are based, Professor Spence adduces the instances of abnormal exaltation of capacity, under trance, mesmerism, somnambulism, and other extraordinary conditions. For my own part, I doubt whether these phenomena have been sufficiently investigated to be turned to this use. We may readily suppose that the hereditary tendencies may be inflamed by mental excitement to the ancestral level; in other words, that I can be made to do, without the full measure of training, all that my forefathers may have attained to. This is like the case of forgotten memories revived in fever. But that I should by being mesmerized, or by being thrown into a trance, perform feats that no one of my ancestors had ever been educated to perform—as, for example, ballet-dancing or rope-walking—is not within the legitimate application of the law of heredity. It would be like water rising above its source. I am not disputing the phenomena themselves; but I think they need some other principles for their explanation, and, if quoted as proving the extent of our hereditary organization, they have the defect of proving too much.

CLEWS IN NATURAL HISTORY.

By Dr. ANDREW WILSON.

IN the exercise of his scientific attainments, there is one aspect in which the naturalist of to-day bears a certain likeness to the detective officer. The latter is perpetually endeavoring to "strike the trail" of the offender through his dexterity in the discovery of clews to the movements of the pursued, and attains his end most surely and speedily when the traces he has selected are of trustworthy kind. The naturalist, on his part, has frequently to follow the history of an animal or plant, or it may be that of a single organ or part in either, through a literal maze of difficulties and possibilities. His search after the relationship of an animal may be fraught with as great difficulty as that which attends the discovery of a "missing heir" or lost relative in actual life; and his success in his mission is found to depend, as does that of the detective's work, simply on the excellence and trustworthiness of the clews he possesses, and on the judicious use to which he puts his "information received." It can not be denied, however, that modern aspects of science and present-day tendencies in research have largely increased the resemblance between the enforced duties of the criminal investigator and the self-imposed task of the biologist. When, formerly, the order of nature was regarded as being of unaltering kind and of stable constitution, naturalists regarded animals and plants simply as they existed. There was of old no looking into the questions of biology in the light of "what might have been," because the day was not yet when change and evolution were regarded as representing the true order of the world. When, however, the idea that the universe both of living and non-living matter had an ordered past dawned upon the minds of scientists, the necessity for tracing that past was forced upon them as a bounden duty. With no written history to guide them, the scientific searchers were forced to read the "sermons in stones" which Nature had delivered ages ago. Without clear and unmistaken records to point the way, they had to seek for clews and traces to nature's meaning in the structure and development of animals and plants; and, as frequently happens in commonplace history, the earnest searcher often found a helping hand where he least thought it might appear, and frequently discovered an important clew in a circumstance or object of the most unlikely kind.

Readers whose tastes are not materially scientific have doubtless heard much of "missing links" of nature, especially in connection with the gaps which exist between the human territory and ape-land. Indeed, the phrase has come to be understood as applying almost entirely and specifically to the absence of connecting forms between man and the apes —forms for which, in one sense, no necessity exists, inasmuch as Mr.

Darwin's theory does not demand that the gorilla or any of his compeers should be directly connected with man. The gorilla with his nearest relation lives, so to speak, at the top of his own branch in the great tree of life, while man exists at the top of another higher and entirely different bough. The connection between the human and lower types is made theoretically to exist at some lower part of the stem when, from a common ancestor, the human and ape types took divergent roads and ways toward the ranks of nature's aristocracy. But although in some cases the need for "missing links" is seen, even theoretically, to be non-existent, or at least of a widely different nature from that supposed by the popular mind, there are yet cases in which that need is very apparent, and wherein, through the persistent tracing of the clews nature has afforded, the past history of more than one race of animals and plants has been made plain and apparent. Of such clews—which are really mere traces, and nothing more—there are no better examples than the curious fragments of structures found in many animals and plants, and named "rudimentary organs." An animal or plant is thus found to possess a mere trace of an organ or part which, so far as the highest exercise of human judgment may decide, is of not the slightest utility to the being. It is invariable in its presence, and as fixed in its uselessness. It bears no relation to the existing life or wants of the animal, but may in some cases—as, for example, in a certain little rudimentary pocket in man's digestive system, serving as an inconvenient receptacle for plum-stones and like foreign bodies—prove a source of absolute disadvantage or even danger. On what theory can the presence of such organs and parts be accounted for? is a question of extremely natural kind. The replies at the command of intelligent humanity are but two. Either the animal was created with the useless appendage in question—a supposition which includes the idea that Nature, after all, is somewhat of a bungler, and that nothing further or more comprehensible than the fiat "It is so," can be said on the subject—or, secondly, we may elect to explain the puzzle by the assertion that the "rudimentary organ" of the existing animal represents a part once fully developed in that animal's remote ancestors, but now

Dwindled to the shortest span.

The rudimentary organ or appendage is represented in the animal of to-day as a legitimate heritage derived from its ancestor. It is, in short, a family feature, to which the animal is the "rightful heir," but which has fallen through the operation of natural laws and conditions into disuse and desuetude, and has accordingly suffered with the career of living nature "down the ringing grooves of change." Necessarily, this second and rational explanation of the rudimentary appendages of animals and plants is founded on the supposition that nature and nature's creatures are continually undergoing alterations, and that they have been modified in the past, as they will be in all time to come. The ex-

planation thus afforded of the nature and origin of these disused parts is endorsed by the fuller knowledge of their history; while, from a study apparently of insignificant interest, may be shown how certain of our living neighbors, along with ourselves, have, from lower states, and from the dawning epochs of the world, literally taken their place "in the foremost files of time."

As most persons who have attentively looked at any common plant can tell, four parts are included in a perfect flower. These parts or sets

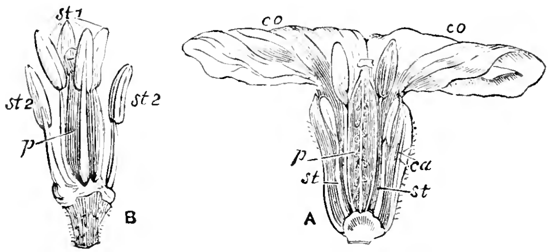


FIG. 1.

of organs, as seen in the wallflower, consist (Fig. 1), firstly, of an outer covering colored green, and named the "calyx" (*ca*). Then comes the blossom or flower itself, forming the "corolla" (*co*). Inside the corolla we find certain stalked organs, each bearing a little head or "anther," filled with a yellow dust, the "pollen." These organs are the "stamens" (*st*). Lastly, in the center of the flower, we note the "pistil" (*p*), or organ devoted to the production of "ovules." The latter, when duly fertilized by being brought into contact with the "pollen" of the stamens, become "seeds," and are capable of growing up, when planted, into new plants. Now, the botanist will inform us that it is a matter of common experience to find some individual plants of a species with well-developed petals or blossoms, and other individuals of the same species with petals in a rudimentary condition, thus proving that the production of imperfect parts in flowers occurs as an ordinary event under our own eyes, and under the common conditions of plant-life. The natural order of plants to which snapdragon belongs presents a peculiarity, inasmuch as in most of its members one of the five stamens is abortive or rudimentary. It should be borne in mind that the botanist possesses a highly interesting and exact method of ascertaining how many parts or organs should be represented in plants. He places his reliance in this respect on the working of what may be called the "law of symmetry." The operation of this law, which may be said to be founded on wide experience, tends to produce a correspondence in numbers between the parts in the four sets of organs of which we have just noted a flower to be composed. Thus, when we count five parts in the green calyx of a plant, we expect to find five blossoms or petals in its corolla; five stamens (or some multiple of five) and five parts (or

some multiple of that number) in the pistil. Where there appears to be a lack of this numerical correspondence, the botanist concludes that some violation of the law of symmetry has taken place, and that some parts or organs which should normally have been developed have been altered or suppressed. His reasoning, in fact, proceeds on the plain basis of first establishing, through experience, the normal number and condition of parts in the flower of any given order of plants, and of thereafter accounting by suppression or non-development for the absence of parts he expected to have been represented.

Now, in the snapdragon tribe, we find, as a general rule, five parts in the calyx, five petals in the corolla, but only four stamens. Such a condition of matters is well seen in the flower of frog's-mouth (*Antirrhinum*), where we find four stamens, two being long and two short (Fig 2, A s^1 s^2), as the complement of the flower. We account for the absence of a fifth stamen by saying it is abortive. But a natural reflection arises at this point, in the form of the query, Have we any means of ascertaining if our expectation that a fifth stamen should be developed is rational and well founded? May not the plant, in other words, have been "created so?" Fortunately for science, Nature gives us a clew to the discovery of the truth in this as in many other cases. In one genus of these plants (*Scrophularia*), we find a rudiment of a fifth stamen (Fig. 2, B *s*), and in snapdragon itself this fifth stamen becomes occasionally fully developed; while another plant of the order (*Mullein*) possesses five stamens as its constant provision. Unless, therefore, we are to maintain that Nature is capricious beyond our utmost belief, we are rationally bound to believe that the rudimentary fifth stamen of *Scrophularia*, and the absent fifth stamen of other plants of its order, present us with an example of modification and suppression respectively. The now rudimentary stamen is the representative of an organ once perfect and fully developed in these flowers, and which it perpetuated by the natural law of inheritance until conditions, to be hereafter noticed, shall have caused it to entirely disappear. The case for the natural modification, and that against the imperfect creation of such flowers, is proved by an ingenious experiment of Kölreuter's, upon plants which have the stamens and pistils situated in different plants, instead of being contained in the same flower, as is ordinarily the case. Some staminate or stamen-possessing flowers had the merest rudiment of the pistil developed, while another set had a well-developed pistil. When these two species were "crossed" in their cultivation, the "hybrids" or mule progeny thus produced evinced a marked increase in the development of the abortive organ. This experiment not only proved that, under

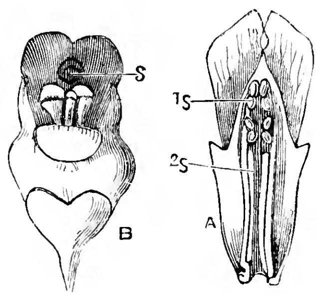


FIG. 2.

certain conditions, the rudimentary pistil could be improved and bettered, but also the identity of the two pistils, and the high probability that the abortive organ in the one flower was simply the degraded representative of the well-developed part of the other.

As a final example of the manner in which we receive clews toward the explanation of the modifications of flowers, the case of the wall-flower is somewhat interesting. This plant and its neighbors possess the parts of the flower in fours. (Fig. 1, A.) There are four sepals and four petals, while six stamens (Fig. 1, B) are developed; the pistil possessing only two parts. Here the law of symmetry would lead us to expect either four stamens or eight—the latter number being a multiple of four. The clew to this modification is found in the arrangement of the stamens. We find that four of the wallflower's stamens are long (Fig. B, st^1), while two (st^2) are short. The four stamens form a regular inner series or circle, the two short stamens being placed, in a somewhat solitary fashion, outside the others. This condition of matters clearly points to the suppression of two of an originally complete outer row of four stamens, and we receive a clew as to the probability of this view by finding that in some other flowers of the wallflower's group the stamens may be numerous. It is hardly within the scope of the present article to say anything regarding the causes of the conditions or of the agencies through which the modifications of plants are wrought out. Suffice it to remark that the "law of use and disuse" of organs explains the majority of such cases, by asserting that organs become degraded when they are no longer found to be useful to the economy of their possessors. The degradation of a part is to be looked upon as subservient to the welfare of the animal or plant as a whole, and thus comes to be related to the great law of adaptation in nature which practically ordains that

Whatever is, is right.

The animal world presents us, however, with more obvious and better-marked examples of rudimentary organs than are exhibited by the modifications of flowers—conspicuous as many of these latter instances undoubtedly are. Turning our attention first to lower life, we find among insects some notable and instructive illustrations of abortive organs, and also of the ways and means through which the rudimentary conditions have been attained. In the beetle order, the natural or common condition of the wings—which in insects typically number four—is that whereby the first pair becomes converted into hardened wing-cases, beneath which the hinder and useful wings are concealed when at rest. Now, in some species of beetles, we may meet with certain individuals with normally developed wings; while in other individuals of the species we find the wings to be represented by the merest rudiments, which lie concealed beneath wing-cases, the latter being actually firmly and permanently united together. In such a case the modifica-

tion has been extreme, but there can be no doubt that the ancestors of the beetles with modified wings possessed fully developed appendages; otherwise we must regard the order of nature as being one long string of strange and incoherent paradoxes. Mr. Darwin has given us some instructive hints regarding the modification of beetles' wings and feet in his remarks on the effects of the use and disuse of parts in the animal economy. Kirby, the famous authority on entomology, long ago noted the fact that, in the males of many of the dung-beetles, the front feet were habitually broken off. Mr. Darwin confirms the observation of Kirby, and further says that in one species (*Onites apelles*) the feet "are so habitually lost that the insect has been described as not having them." In the sacred beetle (*Ateuchus*) of the Egyptians, the tarsi are not developed at all. Mr. Darwin remarks that necessarily we can not, as yet, lay over-much stress upon the transmission of accidental mutilations from parent to progeny, although, indeed, there is nothing improbable in the supposition; and, moreover, Brown-Séquard noted that, in the young of Guinea-pigs which had been operated upon, the mutilations were reproduced. Epilepsy, artificially produced in these latter animals, is inherited by their progeny. "Hence," says Darwin, "it will perhaps be safest to look at the entire absence of the anterior tarsi (or feet) in Ateuchus, and their rudimentary condition in some other genera, not as cases of inherited mutilations, but as due to the effects of long-continued disuse; for, as many dung-feeding beetles are generally found with their tarsi lost, this must happen in early life; therefore the tarsi can not be of much importance, or be much used by these insects."

The beetles of Madeira present us with a remarkable state of matters, which very typically illustrates how rudimentary wings may have been produced in insects. Two hundred beetles, out of over five hundred species known to inhabit Madeira, are "so far deficient in wings that they can not fly." Of twenty-nine genera confined to the island, twenty-three genera include species wholly unable to wing their way through the air. Now, beetles are frequently observed to perish when blown out to sea; and the beetles of Madeira lie concealed until the storm ceases. The proportion of wingless beetles is said by Mr. Wollaston to be "larger in the exposed Desertas than in Madeira itself"; while most notable is the fact that several extensive groups of beetles which are numerous elsewhere, which fly well, and which "absolutely require the use of their wings," are almost entirely absent from Madeira. How may the absence of wings in the Madeiran beetles be accounted for? Let Mr. Darwin reply: "Several considerations make me believe that the wingless condition of so many Madeira beetles is mainly due to the action of natural selection, combined probably with disuse. For during many successive generations each individual beetle which flew least, either from its wings having been ever so little less perfectly developed, or from indolent habit, will have had the best

chance of surviving from not being blown out to sea; and on the other hand those beetles which most readily took to flight would oftenest have been blown to sea, and thus destroyed." An instinct of laziness, so to speak, alone or aided by a shortness of wing, developed stay-at-home habits; and such habits would necessarily tend toward the survival and increase of wingless forms. Other Madeiran insects—such as butterflies, moths, and flower-feeding beetles—have well-developed wings, or possess wings relatively larger than they exhibit elsewhere. This observation, remarks Mr. Darwin, is quite in consistency with the theory of the law of natural selection which favors the survival of the fittest. "For when a new insect first arrived on the island, the tendency of natural selection to enlarge or to reduce the wings would depend on whether a greater number of individuals were saved by successfully battling with the winds, or by giving up the attempt, and rarely or never flying."

Among animals of higher rank in the scale than insects, the presence of rudimentary organs is frequently to be demonstrated. What explanation, other than that of degradation and decay owing to disuse, can be offered of the case of the crabs from the Kentucky Cave? Crabs possess compound eyes borne at the extremities of highly movable stalks, these stalks in the sentinel crab (Fig. 3) being extremely elongated. In some of the Mammoth Cave crabs the stalk remains, but the eye has completely disappeared. As the eyes in such a case could in no sense disappear from any reason connected with injury to the animal, we are absolutely without any reason for their absence other than that of disuse. Professor Silliman captured a cave rat which, despite its blindness, has large, lustrous eyes. After an exposure for about a month to carefully regulated light, the animal began to exercise a feeble sense of sight. Here the modification or darkness has simply affected the function of the eye; in due time the effects of disuse would certainly alter and render abortive the entire organ of sight.

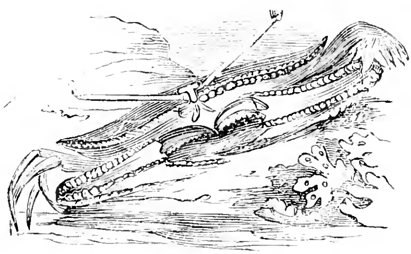


Fig. 3.

The possession of flying powers is so notable a characteristic of the class of birds that any exception to this rule, and the want of aërial habits, may be rightly regarded as presenting us with a highly anomalous state of matters. Yet instances of rudimentary wings in birds are far from uncommon; and several groups are, in fact, more notable on account of the absence of powers of flight than for any other structural features. The ostrich, for instance, represents a bird the wings of which are mere apologies for organs of flight, and which are used, as every one knows, simply as aërial paddles. The curious *Apteryx* or

kiwi-kiwi (Fig. 4) of New Zealand, a near relative of the ostriches and running-birds in general, represents a still more degraded condition of the organs of flight, for the wing is reduced in size to an extraordinary degree, and exists in a highly abortive condition; while only one complete finger is represented in the hand — other birds, as a rule, possessing three modified fingers. The loggerheaded duck of South America has wings so reduced that it can but "flap along the surface of the water," a condition of matters closely imitated among ourselves by the Aylesbury duck—although, indeed, the young ducks are able to fly. The wing of the penguin (Fig. 5) is a mere scaly appendage utterly useless for flight, but useful as a veritable fin, enabling it to swim under water with great facility; and of the auk's wing the same remark holds good. In the

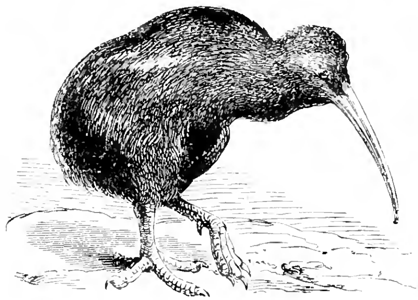


Fig. 4.

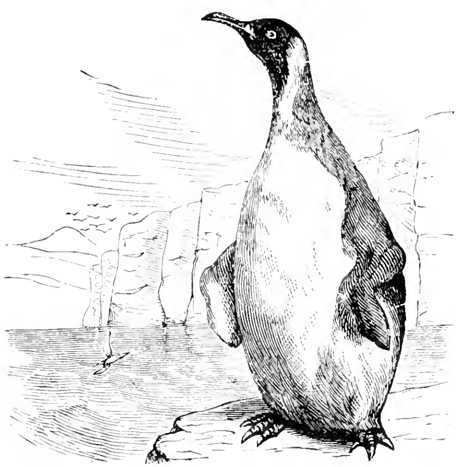


Fig. 5.

birds, then, there is ample evidence of deterioration of organs in the rudimentary nature of the wings of many species. How these conditions have been brought about is not difficult to explain in most instances. In New Zealand, where we find a singular absence of quadrupeds, wingless birds—many being extinct—of which the apteryx is a good example, take the place of the four-footed population. In view of an immunity from the attack of other animals, the ground-feeding habits of these birds would become more and more strongly settled as their special way of life; and, in the pursuit of such habits, the wings,

seldom used for flight, would degenerate as time passed. The later advent of man, in turn, has exterminated certain races of the wingless birds—such as the *Dodo* (Fig. 6) and *Solitaire* (Fig. 7) in Mauritius and Rodriguez—while the wingless and giant Dinornis of New Zealand and its contemporaries have probably been hunted to the death of their species by their human co-tenants of these strange lands.

The ascent to the quadrupeds brings in review before us still more striking illustrations of the apparently incomplete rendering of the structures of animal life. No better instance of the "rudimentary organs" of the naturalist can be found than in the group of the whales, and more especially in the species from which we obtain the commercial whalebone and oil—the Greenland or right whale. This whale possesses no teeth in its adult state, but before birth teeth are found in the gum. These teeth, however, are gradually absorbed, and utterly disappear from the jaws, the adult whale possessing, as is well known, a great double fringe of whalebone-plates depending from the palate. The same remark holds good of the unborn young of ruminants, or animals which "chew the cud"; these animals in their adult state possessing no front teeth in the upper jaw, but in their immature condition devel-

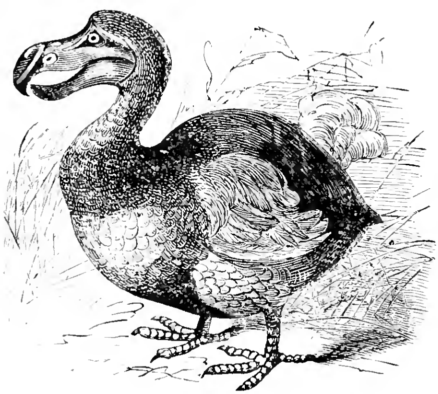


Fig. 6.

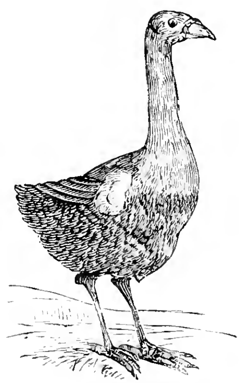


Fig. 7.

oping these organs—which, by the way, never cut the gum—only to lose them by a natural process of absorption. Now, here there can be no question of use; and certainly no adequate explanation of their occurrence exists, save that which regards these fœtal teeth as the remnants of structures once well developed in the ancestors of the whalebone whales and ruminants. To this supposition the evidence—avowedly incomplete—obtained from geology gives no contradiction, even if it does not by any means supply the "missing links" in an adequate fashion. We do know that among the oldest of the great leviathans of the past was the *Zeuglodon*, which had teeth developed much in excess of anything we find represented in the dental arrangements of the

whales of to-day—a creature this, of which, as regards its teeth at least, modern whales are but shadowy reproductions. While under the shelter of great authority we may declare this ancestor of the whale to have been intermediate in nature between the seals and whales, or between the whales and their neighbors the manatees or sea-cows and dugongs. In either case, the intermediate character of the animal argues in favor of its having been the likely parent of a race dentally degraded in these latter days.

There is little need to specialize further instances of the occurrence of rudimentary organs in the higher animals, save to remark that not the least interesting feature of such cases is contained in the fact that the milk-glands of male animals among quadrupeds—organs which exist in a rudimentary condition—have been known to become functionally active and to secrete milk; this peculiarity having been known to occur even in the human subject. Among the higher quadrupeds, however, there yet remains for extended notice one special instance of the occurrence of "rudimentary organs," wherein, not merely is the nature of the parts thoroughly determined, but the stages of their degradation can be clearly traced through the remarkable and fortunate discovery of the "missing links." Moreover, the case in point, that of the horse, so clearly illustrates what is meant by progressive development or evolution of a species of animals, that it is highly instructive, even if regarded from the latter point of view.

When we look at the skeleton of a horse's fore-limb, we are able, without much or any previous acquaintance with the facts of comparative anatomy, to see that it is modeled upon a type similar to that of the arm of man. Were we further to compare the wing of the bird, the paddle of the whale, the fore-limb of the bat, and the fore-leg of a lizard, with the equine limb, we should find the same fundamental type of structure to be represented in all. Thus we find in the arm of man (Fig. 8)—to select the most familiar example from the series just mentioned —a single bone, the *humerus* (3), forming the upper arm; two bones (*radius* (4) and *ulna* (5)) constituting the fore-arm; eight small bones forming the wrist (*carpus*): five bones—one for each finger—forming the palm or *metacarpus;* and five fingers, each composed of three small bones, named *phalanges*, with the exception of the thumb, in which, by a mere inspection of that digit, we may satisfy ourselves only two joints exist. In the wing of the bird (Fig. 9) we find similarly an upper-arm bone or *humerus*, two bones (*radius* and *ulna*) in the forearm; a wrist (*b*), a thumb (*g*), and two fingers (*c f e d*). Now, turning to the fore-limb of a horse (Fig. 10)—the hind-limb being essentially similar, in its general conformation, and corresponding as closely with man's lower limb—we find its conformation to correspond in a remarkable fashion to that

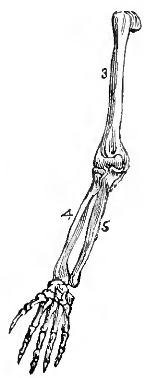


FIG. 8.

of man's arm. First, there is the *humerus* (*h*), a bone of the horse's upper arm, concealed, however, beneath the skin and muscles, and being, therefore, inconspicuous in the living animal. The horse's forearm, like that of man, contains two bones—*radius* (*r*) and *ulna* (*u*)—it is true; but the *ulna* has degenerated in a marked degree, and exists as a mere strip of bone which is tolerably distinct at its upper end, but unites with

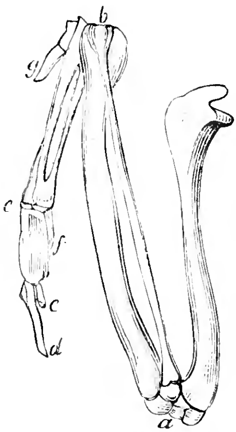


Fig. 9.

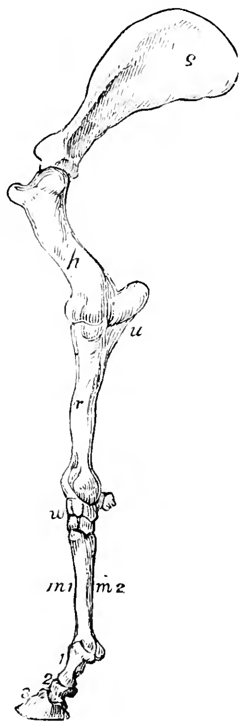


Fig. 10.

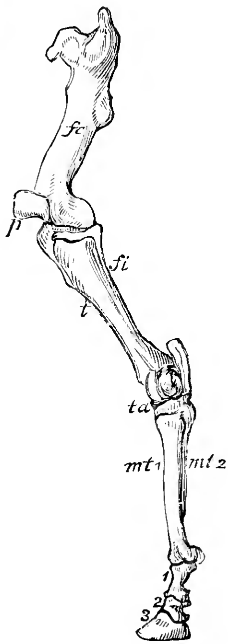


Fig. 11.

and merges into the other bone, the well-developed *radius*. The wrist (*w*) of the horse naturally succeeds its forearm, but from the fact of the upper arm being concealed beneath the skin and muscles, the wrist is commonly mistaken for the horse's knee. Thus, when a horse chips its "knee," it in reality suffers a contusion of its wrist. Man possesses eight bones in his wrist, the horse has only seven, but the equine wrist is readily recognizable as corresponding with the similar region in man. The greatest difference between the human limb and that of the horse is found in the regions which succeed the wrist, and which constitute the palm and hand. Man has five palm-bones: the horse has apparently but one long bone, the "cannon-bone" (m^1), in place of the five. Now, to which of man's palm-bones does this "cannon-bone" correspond? The anatomist replies, "To that supporting the third or middle finger"; and attached to this single great palm-bone the horse has

three joints or "phalanges" (1, 2, 3) composing his third finger. These joints are well known in ordinary life as the "pastern," "coronary," and "coffin bones"; and the last bears the greatly developed nail we call the "hoof."

Thus the horse walks upon a single finger or digit—the third; and it behooves us to ask what has become of the remaining five—the highest number of fingers and toes found in mammals or quadrupeds? We find that, with the exception of other two—the second and fourth fingers —the horse's digits have completely disappeared. The second and fourth fingers have left mere traces, it is true, but it is exactly these rudimentary fingers which serve as the chief clews to the whole history of the equine race. On each side of the single palm-bone of the horse's great finger, we see two thin strips of bone (one of which is represented at m^2 Fig. 10), which veterinary surgeons familiarly term "splint-bones." (See also Fig. 12 A, *d*). But these "splints" bear no finger-bones, and the condition of the horse's "hand" or fore-foot is therefore seen to be of most noteworthy and curious conformation. It may, indeed, sometimes happen that the small pieces of gristle or cartilage may be found at the base of the splint-bones, and comparative anatomists incline to regard these gristly pieces as the representatives of the first and fifth fingers. But the ordinary condition of the horse's hand may be summed up by saying that the animal walks on one well-developed finger—the third—and possesses the rudiments, in the form of the "splint-bones," of other two fingers, the second and fourth. These latter, it need hardly be added, are completely concealed beneath the skin and other tissues of the limb. In the hind-limb of the horse (Fig. 11), a similar modification is observed. The thigh-bone (*f e*) and knee-cap (*p*) are readily observed. There is but one toe—the third (^{1}, ^{2}, ^{3})—supported by a single cannon-bone (mt^1); and there are likewise two splint-bones (one depicted at m^2), representing the rudiments of the second and fourth toes. The horse's heel, like his wrist, appears out of place, and is popularly named his "hock." The shin-bone (*t*) is the chief bone of the leg, and has united to it the other bone (*fi*) succeeding the thigh, named the fibula, and which is seen in man's leg, and in that of quadrupeds at large.

To the eyes even of an unscientific observer, who sees the skeleton of a horse placed in a museum, in contrast with the bony frames of other and nearly related animals, the equine type is admittedly a very peculiar and much modified one. In place of five toes, we find but one; and in the matter of its teeth, as well as in other features of its frame, the horse may be said to present us with an animal form which appears as a literal example of Salanio's remark that

> Nature hath framed strange fellows in her time.

A person of a thoroughly skeptical turn of mind might possibly demand to know the exact reasons for the assumption that the splint-

bones of the horse are in reality the rudiments of the fingers we have represented them to be, and might further demand proof positive of their nature. Fortunately, geology and the science of fossils together come to our aid, with as brilliant a demonstration of the steps and stages of the degradation of the horse's fingers as the most sanguine evolutionist could hope to see. From Mother Earth, whose kindly shelter has sufficed to preserve for us the remains of so many of the forms of the past, we obtain the means for constructing a genealogical tree of the equine race, by methods of certain kind, and through the exhibition of fossils, each bearing an impress of its history, which, to use Cuvier's expression, "is a surer mark than all those of Zadig."

Our theoretical journey backward into the ages begins with the Recent or last-formed deposits—those which lie nearest the outer surface of our earth. The Recent or Quaternary period forms a division of the Tertiary period, that is, the latest of the three great epochs into which, for purposes of classifying fossil forms by their relative ages, the geologist divides the rock-formations. The Tertiary rocks, commencing the list, with the last-formed or uppermost strata, begin with the Quaternary or Recent deposits; next in order succeed the older Pliocene rocks; then come the Miocene formations, and lastly succeed the Eocene rocks. These last are the oldest of the Tertiary period, and lie in natural order upon the Cretaceous or Chalk Rocks, which themselves belong to an entirely different and anterior (Mesozoic) period in the history of our globe. The first fossil—that is, the last-deceased—horses we meet with are found in the Quaternary and Pliocene, or the last-formed deposits of the Tertiary system. Between these earlier Pliocene horses and our own Equidæ there are no material differences; and the limbs of these forms may therefore be diagrammatized as depicted in Fig. 12, A A^1; the cannon-bone in all of these figures being marked *a*; the splint-bones *dd*; the "pastern" and "coronary" bone *b*, *c*, and the "coffin-bone" *f*.

But near the beginning of the Pliocene formations of the Old World, and in the oldest of the Miocene rocks which lie below them, we find a member of the horse family which differs in certain important respects from the horses of the Recent period, and from those of to-day. The fossil horses alluded to are found not merely in Europe, but in the Sewalik Hills in India, and they must therefore have possessed a very wide range of distribution. When first discovered, M. de Christol called this species of horse *Hipparion*, a name which has been still retained for it, amid that constant alteration in zoölogical nomenclature which is the labor of the foolish and the sadness of the wise among us. What are the chief peculiarities of Hipparion? Briefly stated, in the larger development of the "splint-bones" (Fig. 12, C C^1), which, according to Owen, must have "dangled by the side of the large and functional hoof (or third toe) like the pair of spurious hoofs behind those forming the cloven foot in the ox." This conformation, continues Owen, "would

cause the foot of the Hipparion to sink less deep into swampy soil, and be more easily withdrawn than the more simplified horse's foot." Furthermore, the ulna or bone of the forearm, deficient in the horse of to-day, is tolerably well developed in Hipparion.

Backward in time, and in the older Miocene formations of Europe, another fossil horse was disentombed, and was duly described under the name of *Anchitherium*. This latter horse possesses a completely developed ulna in the forearm, and fibula in the leg; but its chief point of interest lies in the fact that each foot possessed three fully developed toes (Fig. 12, D D¹ *d*, *d*, *c*) which apparently must have touched the

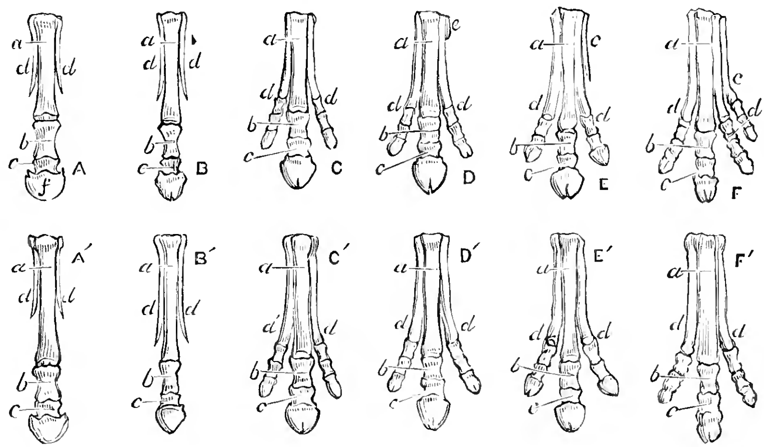


Fig. 12.

ground in walking. Already, our splint-bones are seen to better their condition as we pass backward through the ages, and to appear as the natural supports of well-developed second and fourth toes. Here the geological history of the horse in the Old World may be said practically to end. Modern history assures us that the first horses which peopled the New World, and whose descendants roam over American prairies as the famed mustangs, were imported by the Spaniards at the period of the Mexican conquest. Geology has a more curious tale to relate of the New World horses and their history, and gives them an antiquity compared with which the events of man's primitive history in either world are but as yesterday. Recent researches among the rock formations of Western America, in particular, have shown us that it is to the New World we must look for a perfect pedigree of the horse. For, beginning with the horse of to-day, with its splint-bones, we are carried gradually backward in time to the Pliocene horse of the New World named *Pliohippus* (B B¹)—a form not differing materially from the living horse, but serving in a very graduated fashion to introduce us to the older *Protohippus*, the New World representative of our own fossil Hipparion (C C¹), and in some respects a more typical three-toed

horse than the latter. Our own Anchitherium (D D') corresponds to the next specimen of the New World—*Miohippus* by name; and Miohippus evinces a still more important modification in that it possesses a rudiment of the fifth or little finger in addition to the second, third, and fourth digits with which the fore-feet are provided.

The American horses now continue the history of the race in time past without aid or representative from the eastern hemisphere, in so far, at least, as the latest research has shown. To Miohippus succeeds the *Mesohippus* (E E') from the American Miocene, which has three well-developed toes, and in addition shows the rudiment of the little finger (E *e*) of the fore-feet (seen also in Miohippus, D *e*) in an enlarged condition. Passing to the Eocene formations, the oldest series of the Tertiary rocks, we meet with the next step in the form of the *Orohippus* (F F'), in which the little finger (*e*) appears as a veritable member of the hand, the hind-feet still possessing three well-developed toes only: while, consistently with the development of the toes, the ulna of the forearm and fibula of the leg appear as bones of legitimate size, and present a striking contrast to their rudiments in the horse of to-day. The last discovered horse is from the oldest of the Eocene beds; it has been appropriately named *Eohippus*, and presents us with four complete toes (second, third, fourth, and fifth) on the fore-feet, and a rudiment of the first toe as well; with a trace of the fifth toe of the hind-feet—this last member being, as we have seen, unrepresented in any of the other forms. When the Chalk Rocks shall have yielded up their fossil horses, it is consistent with logic and reason to expect that the primitive stock of the horses will be discovered with its complete provision of five toes, and its corresponding modifications of form.

To what conclusions, of reasonable kind, do these stable facts regarding the pedigree of the horse naturally lead? The answer is toward a belief in the slow and progressive modification and evolution of the one-toed modern horse from a five-toed ancestor. This process of modification must, of course, have affected its entire frame, but it is sufficient for our present purpose to point out that in the structure of the foot alone we discern the evidence for evolution, as clearly as in the entire organization of the animal. An increase of speed, and obvious advantage over its enemies, would be gained by the horse, as its toes grew "small by degrees and beautifully less"; and the single-toed race has thus practically come to the front in the world of to-day, as the plain and favorable result of the work of degradation among its digits.

Two bony shreds or rudiments thus lay the foundation of a grave conclusion regarding the horse and its manner of development, and exemplify the adage that great and unlooked-for results sometimes spring from beginnings of apparently the most trifling kind. The "splint-bones" form, in fact, a clew which, when rightly pursued, leads not merely to a knowledge of the evolution of the horse, but to an understanding of the entire scheme of nature. The idea, then, of

"special creation" of the horses does not look well, it must be confessed, in the face of the gradual and obvious modification exhibited by the series of fossil horses, which leads without a break from Eohippus to the modern horse. At most, it may be said, there is but a choice of probabilities offered us. And in the adoption of a scheme of development, and in face of the facts laid before us, it is hard to see any grounds whereon the special-creation theory can be maintained, or the theory of progressive development and evolution denied. For if evolution is the law of the horse's history, it must logically follow that it represents the scheme of nature throughout : since the uniformity of nature, in which we are bound to believe, and to which we are bound to appeal, would utterly negative the idea that evolution should hold good for the horse, and be inapplicable to any other living thing. Because the missing links are not so completely supplied to us in other cases as in the horse, we are not on that account entitled to assume that the theory of development is invalid. We may not see an oak-tree grow inch by inch, but we are as positive as our mental nature will admit, that the oak was once an acorn, and that there has been a progressive growth and increase which might not be apparent to us were we to watch the tree for weeks together. Applying this reasoning to the case before us, it would be as illogical to deny that the order of nature was that of development, as to insist that the oak was created as it stands. The extent of human knowledge, and the duration of human existence, are together inadequate to enable us to discern the progress of this world's order after the fashion whereby, from a lofty elevation, we may trace every winding of a stream. But the probabilities of the case are as overwhelmingly for progressive development, as the direct evidence at hand—exemplified by the horse's pedigree—tells against special and independent creation having been the way of the First Cause in the making of the world and its living things.

The entire scheme of scientific discovery thus depends very largely upon the use made of the hints which nature is continually presenting to the searcher, and on the correct interpretation of the facts he is fortunate enough to elicit in his search. The study of the rudiments of animal and plant structures may well exemplify, from the importance of its results, the value of gathering up the veriest fragments of knowledge. For, as Mr. A. R. Wallace has remarked regarding rudimentary organs, "There must be a cause for them; they must be the necessary results of some great law." And again are this author's words most appropriate when he says: "Many more of these modifications should we behold, and more complete series of them, had we a view of all the forms which have ceased to live. The great gaps that exist between fishes, reptiles, birds, and mammals (that between reptiles and birds is now wellnigh obliterated) would then, no doubt, be softened down by intermediate groups, and the whole organic world would be seen to be an unbroken and harmonious system."—*Gentleman's Magazine.*

DIETETIC CURIOSITIES.

BY FELIX L. OSWALD, PH. D., M. D.

II.

WE know from the accounts of Sir John Ross, Captain Kane, and other Arctic explorers, how persistently the Esquimaux prefer walrus-blubber and whale-oil to the most seductive products of the vegetable kingdom, but the fervor of their devotion was only realized by the Rev. Mr. Hansen, the Moravian missionary, who prepared a dying Esquimau for the glories of the New Jerusalem. "I am sure you are right," said the departing brother, "but, tell me, are there many walruses in heaven?" "None at all, as far as I know," Mr. Hansen replied, not without astonishment at the question. The weary eyelids opened to emit a look of intense reproach. "And you couldn't tell me that before? No heaven that for me, then—an Esquimau can not subsist without walrus!"

The peptic stimulus of a high latitude, as recognized by Dr. Boerhaave, may justify such preferences; but Greenlanders, carried down to our temperate climate and even to the eternal summers of Cuba, still insisted on their daily blubber-ration with a firmness worthy of a better cause. Ferdinand Renz, the European Barnum, found it to his advantage to gratify the national taste of his Greenlanders. He had attempted to wean them from their traditional grease, and nearly succeeded, as he flattered himself, when his managers reported an enormous deficit of tallow-candles, which he found had been devoured by the boxful in the silence of night by the bereaved children of the North.

Nowhere is indifference to the quality of food carried further than in the rural districts of Russia. Black, sour bread, salt pork, cabbage, and *quass*, or fermented cabbage-water, are the nectar and ambrosia of the Slavonic boor, who in times of scarcity will content himself with a diet that would drive Munster and Connaught to desperation. Quass, their popular tipple, is described as resembling a mixture of stale fish and soap-suds in taste, yet has next to beer probably more votaries than any other fermented stimulant.

Assassin, *assassinate*, and their derivatives come from *hasheesh*, the Arabian word for hemp. A decoction of hemp-leaves, filtered and boiled down, yields a greenish-black residuum of intensely bitter and nauseous taste—a stuff not very likely, one should think, to tempt a normally constituted human being. Yet this same hasheesh, Dr. Nachtigal assures us, can marshal a larger army of victims than either gunpowder or alcohol; and only the originator of the opium-habit, he thinks, will have an uglier score against him on the day of judgment than the Sheik-al-Jebel, who, tradition says, first introduced the hasheesh-habit.

The effect of this hemp-extract is compared to hydrophobia: its votaries are seized with rage and restlessness, and if the paroxysm is upon them seize a knife, a stone, or anything that will serve for a weapon, and rush out to commit indiscriminate assaults, continuing to "run amuck," as the Malays term it, till the stimulating power of the drug has spent itself, or till their career is stopped by a well-aimed shot. In Batavia and other cities of the Dutch Indies there used to be a standing reward for the slaying of a "muck-runner," but even such a man as Ibrahim Pasha was not ashamed to stimulate the courage of his soldiers by the use of the detestable poison. The hasheesh-habit originated in Asia Minor, but is now practiced throughout northern Africa down to the Abyssinian valleys, and has spread eastward to the Malay Archipelago, and even to Siam, where its further progress was arrested by the determined action of the Siamese Government.

A frugal diet has this additional advantage, that simple food is in less danger of adulteration, or must at least be imitated by equally simple and harmless substitutes. Watered milk or lard mixed with corn-meal is certainly annoying, but hardly injurious, and is a trifle altogether if compared with the abominations that are half consciously consumed by the lovers of imported delicacies and expensive stimulants. Dr. Stenhouse, of Liverpool, analyzed a suspicious sample of tea, with the following result, published in the "Planters' Price Current" of February, 1871 : The package contained some pure congou-tea leaves, also siftings of pekoe and inferior kinds, weighing together twenty-seven per cent. of the whole. The remaining seventy-three per cent. were composed of the following adulterants : Iron, plumbago, chalk, china-clay, sand, prussian blue, turmeric, indigo, starch, gypsum, catechu, gum, the leaves of the camellia, sarangua, *Chlorantes officinalis*, elm, oak, willow, poplar, elder, beach, hawthorn, and sloe.

There is hardly any article of food in general use which has not somewhere been converted into a stimulant by the process of fermentation. What else are whisky, rum, beer, etc., but fermented or distilled bread, the bread-corn diverted from its legitimate use to produce an artificial stimulant? Potatoes, sugar, honey, as well as grapes, plums, apples, cherries, and innumerable other fruits, have thus been turned from a blessing into a curse. The Moors of Barbary and Tripoli distill an ardent spirit from the fruit of the date-palm, the Brazilians from the marrow of the sago-tree and from pineapples, and even the poor berries that manage to ripen on the banks of the Yukon have to furnish a poison for the inhabitants of Alaska. Pulque, the national drink of Mexico, is derived from a large variety of the aloe-plant, the sap of which is collected and fermented in buckskin sloughs into a turbid yellowish liquor of most vicious taste.

Cheese, in fact, is nothing but coagulated milk in a more or less advanced state of decay. Sauerkraut is cabbage in the first stage of fermentation, which if completed yields quass, the above-mentioned Rus-

sian tonic. Chica, a whitish liquid which in Peru is handed around like coffee after meals, is prepared from maize or Indian corn, moistened and fermented by mastication.

How a fondness for such abominations is propagated can be explained by any boy who had to drink beer or eat strong cheese against his will, and by and by "rather liked it," but a question less easily answered is how such tastes ever could originate. To the first man who tasted hasheesh, alcohol, or pulque, these substances could hardly be more tempting, we should think, than coal-tar or caustic sublimate. But most articles of food and drink are older than history. All we can do is to trace their progress from nation to nation and from century to century, but their origin loses itself in the cloud-land of tradition. The exegesis of diet is as problematic as that of religious dogmas.

Natural characteristics can frequently be traced to an hereditary foible for a special diet. French wits unhesitatingly attribute the *têtes carès* of their eastern neighbors to the heavy black bread of the land of Thor, and hint strongly that the reticence and stubbornness of John Bull have more to do with his beefsteaks than with mental profundity.

"Alas, how helpless is theology against the diet of bull-beef!" writes Father De Smet in his yearly report from the Sioux missions. It certainly is a suggestive fact that agriculture had to precede Christianity in its conquests over the aboriginal North Americans. Not one of our Indian tribes would renounce the devil and all his works unless we could get them to renounce the buffalo first. I heard a vegetarian lecturer in New Orleans last year, who gave a *résumé* of the peculiar views of his people, and certainly made out a very strong case in their favor. "The aggressive, the belligerent, and bloodthirsty instincts of all nations," he said, "are exactly equal to the proportion of animal food in their diet. The Hindoos, who like pigeons seem to be 'born without gall,' are vegetarians from birth; so were the Lotophagi of antiquity, who compromised all differences by arbitration. The Malays, who, in the same climate and with the same advantages, make use of animal food, are notoriously cruel and quarrelsome. But in the Indians of North America, who are wholly carnivorous, human nature and native pity seem to have become extinct, and superseded by an artificial instinct of bloodshed which equals that of the most ferocious animals."

The Mexicans distinguish between *Indios mansos* and *Indios bravos*—tame and fierce Indians—between whom there seems to be no generic difference; but the eastern tribes are frugivorous, cowardly, and harmless as Hindoos, though in stature and facial characteristics exact copies of their western kinsmen, the flesh-eating Comanches, who in cruelty emulate the pirates of Malacca.

Erasmus complains of the porcine paunches and materialistic tendencies of his countrymen, and warns them that, when eating and drinking have become the objects of life, animalization will speedily follow.

"It was thus," he facetiously remarks, "that Circe changed the companions of Ulysses into pigs."

It is certain that the monastic gluttony of Austria, Bavaria, and the adjoining states, where plethoric convents abound, has developed an unmistakable type of grossness in the characteristic physiognomies of those countries. The *ingenium pingue* which Ulric Hutten satirizes is still an hereditary affliction in many Catholic districts, and nowhere more than in Austria proper, in Linz and Vienna, where the art of cookery has become the problem of life, and "the instinct of liberty is drowned in sausage-fat."

Abstinent habits, too, begin to set their mark if continued to the second or third generation. The ascetic vigor of Semitic countenances probably dates from the establishment of the Mosaic and Islamitic codes, with their rigid dietetic restrictions, and something in the spiritualistic eyes of the Arabian desert-dwellers suggests the absence of those animal brain-elements which according to Dio Lewis are assimilated like trichinæ by the use of pork and beef. But only a French *savant* can go so far as to reconstruct the entire national history of a race from such physiognomic indications. "The face of a Turk," says M. de Chateaubriand, "shows the high cheekbones and powerful, bone-crushing jaws of the original Turkoman shepherd, improved by a diet of Attic figs and Thessalian grapes, further sweetened by the sherbet and perfumed cakes of Constantinople, and finally clouded by the fumes of opium!"

"There is a sadness in the face of the typical Chinese," writes the Rev. Mr. Gentz, "which now always moves me to infinite pity. At first they were vaguely repulsive to me, these death-head profiles and sad, sunken eyes, but I can interpret them now, and they speak to me of centuries and centuries of dull, hopeless suffering by slavery, poverty, and loathsome or insufficient food." If we believe that Dr. Fowler was able to distinguish the weavers from other operatives of a miscellaneous manufactory, merely by the formation of their heads, we can not consistently call even Chateaubriand a visionary, for "alimentativeness" is one of the recognized organs of the craniological systems. A certain amplitude of the region between the ear and the posterior base of the skull indicates gormandism to the followers of Dr. Gall, and excessive development, therefore, of gluttony and voracity. A happy illustration if not demonstration hereof is the preserved bust of Vitellius, the imperial arch-glutton, whose enormous head seems only a reduced continuation of the still more enormous neck. Lavater, the father of Physiognomy, describes the "*Fresser-Falte*" or gormand's wrinkle which in his opinion is developed by a certain movement of the cheeks which makes us say, "His mouth waters," and by which he thinks he could detect an Austrian abbot in any disguise.

On the moral effect of sundry articles of food, Dr. Bock, the Leipsic professor, and author of the famous "Buch vom gesunden und kranken Menschen" ("Man in Health and Disease"), discourses as follows:

"Flesh-food imparts courage, but also aggressive moods and bad temper, with intervals of gloom and hypochondria; excessive use of pork can produce a mental nausea, known to the Hungarians as the *Tzömör*, which may lead to insanity and suicide. The ichthyophagous tribes of northern Siberia are rendered stupid and sluggish by an exclusive diet of fish. Fish and fowl in moderate quantities and in combination with vegetable food, produce no appreciable injurious effects. The influence of ripe fruit is benign, exhilarating without the eventual reaction that always follows alcoholic excitement. Milk, too, especially the rich milk of sheep, has an assuaging, mildly cheering effect even on hypochondriacs and dyspeptics. Pure fat of any kind exercises a calming influence on excited passions, but if long continued as an article of diet tends to somnolency and lassitude. Strong cheese operates as a sedative and a check to the activity of the brain-functions—makes us stupid in other words, and can also result in a half-physical, half-psychical dejection not dissimilar to the *Tzömör*.

"Wheat-bread is neutral, a most excellent though not all-sufficient article of food, and, like a blank sheet of paper, serves as a foil to whatever you may combine it with, while sour rye-bread is a tonic and reacts on the temper in a feeble way. Eggs, raw or soft-boiled, are more nourishing than meat, stimulate muscular activity, and produce reflective rather than vindictive moods. Sugar alone, or preponderating in made dishes, causes vague uneasiness in some and merriment and wantonness in other constitutions, but moderately combined with farinaceous substances and fat, is inferior only to fruit as an alimentary corrective. Potatoes and the legumina (beans, peas, and lentils), inasmuch as they are farinaceous, are a legitimate article of food, yet not as healthy as the cereals. They lack the brain-forming elements, and, though like bread they might sustain life, they would operate depressingly—produce weariness and *ennui*, without the addition of saccharine and sub-acid food.

"The nervousness and peevishness of our times are chiefly attributable to tea and coffee; the digestive organs of confirmed coffee-drinkers are in a state of chronic derangement, which reacts on the brain, producing fretful and lachrymose moods. Fine ladies, addicted to strong coffee, have a characteristic temper which I might describe as a mania for acting the persecuted saint. Chocolate is neutral in its psychic effects, and is really the most harmless of our fashionable drinks. The snappish, petulant humor of the Chinese can with certainty be ascribed to their immoderate fondness for tea. Beer is brutalizing, wine impassions, whisky infuriates, but eventually unmans.

"Alcoholic drinks combined with a flesh and fat diet totally subjugate the moral man unless their influence be counteracted by violent exercise. But with sedentary habits they produce those unhappy flesh sponges which may be studied in metropolitan bachelor-halls, but better yet in wealthy convents. The soul that may still linger in a fat Austrian

abbot is functional to his body only as salt is to pork—in preventing imminent putrefaction."

Essays on diet gravitate toward the Austrian abbot, it seems. But the importance of the three daily meals was indeed wonderfully enhanced by the tedium of convent-life. The god *Venter*, Ulrich Hutten insinuates, was ever of more consequence to the holy fraternity than all the saints of the Roman calendar, and the greatest miracle in their estimation is the feeding of the five thousand with five loaves of bread. With few exceptions the abbeys and prebendaries of mediæval Europe were strongholds of gluttony, the well-appointed receptacles of the *viri amplissimi* who carved the board of the dinner-table for the reception of their ample paunches, and whose faces shone at the aspect of a favorite dish as the countenance of Moses on Sinai. Their fasts in Lent were really a satire on the *bona fide* and chronic fasts of the poor; pastry, puddings, and eel-pies in lieu of the normal venison haunches, and butter instead of ham-fat, helped to sweeten the time of penance; and Erasmus mentions the prior of an abbey who instructed his major-domo to reduce the accustomed number of dumplings for the sake of Good-Friday: "Make only ten to-day," said the pious prelate—"but," after some reflection, "you can make them—a little larger."

Of what transcendent interest the bill of fare must have been to Cardinal Dubois, who called on the dying Fontenelle at his boarding-house! The landlord announcing asparagus for dinner, and asking instructions in regard to the desired sauce, provoked an animated controversy between the two dogmatists. Fontenelle insisted on cream, the Cardinal on melted butter, till the landlord suggested a compromise—he would divide the material and use a separate sauce for each half. But Fontenelle was not destined to eat that dinner—his day of life was ended by a stroke of apoplexy before the sun had reached the meridian. Dubois, who had recognized the sad fact with a paroxysm of grief, then rushed to the landing and shouted down the memorable words, "Mettez tous au beurre!"—(Butter-sauce for the whole lot!)

Twenty per cent. of the French revenues were ingulfed by the *cuisine* of Louis le Grand, and other court kitchens have furnished very strong arguments to the opponents of royalty. During the ante-Napoleonic era of small German principalities, more than one of those "commanders of four faithful square miles" astonished the world by selecting a Secretary of the Treasury from his staff of French cooks; but they who wondered did not know what secrets those functionaries could have revealed to a committee of ways and means. Peter the Great, at his departure from Castle Waldeck, where he had been feasted as the guest of the sovereign proprietor for some days, was asked to give his opinion of the château. "Everything is splendid," replied the ingenuous Russian, "only the kitchen is too large."

Such kitchens and their products have often deserved the attention of the historical pragmatist. An indigestible mushroom stew provoked

King Philip's edict against his Protestant subjects and thus caused the revolt of the Netherlands, and the historical eel-pie that extinguished the house of the Medici aided the cause of the Reformation more than all the armies of Sweden and Brandenburg. Mohammed II., the conqueror of Constantinople, we learn from Raumer's history, had an attack of gastritis after finishing a highly seasoned dish of broiled liver. As a matter of course the responsible cook was put to death at once, but the pains and the rage of the Sultan were not appeased, and with his own hand he stabbed Demetrius Phranza, his beautiful favorite, son of the late chief minister of the fallen Greek Empire. By this barbarous act he alienated the hearts of his Christian subjects for ever, and planted the seeds of that hatred which perhaps at this moment bears its harvest on the battle-field of Bulgaria. That dish of sour milk and rye-bread which Charles II. had to eat in his haystack after the battle of Worcester seems never to have been digested by the house of Stuart, though it might have imparted a lesson more useful to the "merry monarch" than any precept of the Scotch Covenanters.

Frederick the Great, who proved himself the master spirit of Europe by such incontrovertible arguments, was himself mastered by his fondness for certain French-made dishes, which, according to Dr. Zimmermann, shortened his life by at least ten years. One of his odes, addressed to Monsieur Noël, his *caterer-en-chef*, dwells rapturously on the merits of a peculiar partridge-pie. "Not, though, as if I doubted that such pies will send me and you *à l'enfer*," Frederick added in prose after reading this production to Noël himself. "I would follow your majesty even there," returned the courteous cook, "and it is a consoling circumstance that neither of us two is afraid of fire."

We have no Roman Pollios who chopped up a couple of young slaves every week to improve the flavor of their carps; but it is said of the Empress Elizabeth of Russia that during her residence in Moscow she caused the death of more than one courier, who had to bring in oysters and fresh sea-fish from the coast within a specified time. Domitian, the impulsive Imperator, once actually assembled the Roman Senate in special session to vote on the merits of a new sauce which he desired to try on a fat specimen of *Rhombus maximus*, the Mediterranean turbot! Ælius Verus, whose administration of Asia Minor had drained the wretched province of all its available cash, spent the produce of his rapacity in less than four years in his voluptuous retreat of Daphne, or in the riots of Antioch, where it is said that a single entertainment, to which only about a dozen guests were invited, cost above six million sesterces, or nearly $240,500.

A cook in those times could often earn a talent ($1,200) a day, which sum, Petronius remarks, would have sufficed to hire a dozen philosophers for a year. It was the age of complete degeneration of the once so frugal Romans, who now tolerated men like Pyttilus, who got an asbestos sheath fitted to his tongue to enable him to swallow the hottest

dishes and spices with impunity; or Aristolenus, who longed for the throat of a crane, that he might prolong the bliss of deglutition. Tacitus speaks of a particular dish, called the shield of Minerva, the ingredients of which cost sixty talents ($72,000), and which the ineffable Vitellius had at different times prepared at that price—an insanity which we may hesitate to believe; but less than a century ago the city of London treated George III. to a banquet of three hundred and fourteen "courses," at an expense of twenty-six thousand pounds sterling.

Opposite the Palais Royal, along the Chaussée d'Antin and on the Rue Rivoli, Paris, there are restaurants where a moderate fortune may be spent in a single week, and the *déjeuners-dînatoires* of the Frères Provençaux are not forgotten where some piquant made dishes would cost more than a year's board in the Faubourg St.-Germain.

"They offered me an *omellette* at Fitchburg," says Henry Thoreau, "an omellette with fried bacon, at forty-five cents. Not having forty-five cents to spare for an indigestion, I bought some bread and butter, which, together with the apples I had, made me a fine dinner. We *do* need some fat and farinaceous substance once a day, but, if one can get it out of a butter sandwich and ten cents, he commits a crime against national economy and against himself if he wastes the fourfold price on an omellette and fried bacon. And why commit a further waste by calling the thing an o-mel-lette? Are not the two syllables of a pancake sufficient?"

Whatever may have been the intrinsic value of that pancake, it would certainly be worth forty-five cents to know what Henry Thoreau would have said about the following *menu* of a "little lunch," given at the Langham Hotel (London) to the members of the Dietary Reform Club (society for the introduction of horse-flesh):

Potages—Consommé de cheval. Purée de destrier. *Amontillado.*

Poissons—Saumon à la sause arabe. Filets de soles à l'huile hippophagique. *Vin du Rhin.*

Hors-d'œuvres—Terrines de foie maigre chevalines. Saucissons de cheval aux pistaches syriaques. *Xérès.*

Releves—Filet de Pégase roti aux pommes de terre à la crême. Dinde aux châtaignes. Aloyau de cheval farci à la centaure et aux choux de Bruxelles. Culotte de cheval braisée aux chevaux de frise. *Champagne sec.*

Entrées—Petits pâtés à la moëlle-Bucéphale. Kromeskys à la gladiateur. Poulets garnis à l'hippogriffe. Langues de cheval àla troyenne. *Château perayne.*

SECOND SERVICE.

Rôts—Canards sauvages. Pluviers. Mayonnaises de homard à l'huile de Rossinante. Petits pois à la française, choux-fleurs au parmesan. *Volney.*

Entremets—Gelée de pieds de cheval au marasquin. Zéphirs sautés à l'huile chevaleresque. Gâteau vétérinaire á la Ducroix. Feuillantines aux pommes des Hespérides. *Saint-Peray.*

Glaces—Crême aux truffes. Sorbets contre-préjugés. *Liqueurs.*

Dessert—Vins fins de Bordeaux. Madère. Café.

Buffet—Marmalade au kirsch, gâteau d'Italie au fromage de Chester, etc., etc.

The Langham has been eclipsed by some Regent Street club-rooms, if not by Delmonico's, but Paris is still the Mecca of epicures, and even during the Prussian siege Baron Brisse would have undertaken to improve on the above *menu*. Next, perhaps, comes St. Petersburg with its *mislanitza* and caviare-suppers, then London, New York, and the city that derives its name from ham-sandwiches, as Heine suggests.

The champion belt of Apicius belongs probably to Count Luckner, a Russian dignitary of vast estates in the government of Smolensk, and for a time ambassador at the court of Vienna, where he left because Herr Saphire called him an emotional swill-barrel! At his country seat of Ranzow he is said to receive a daily *programme de cuisine* from his major-domo, which he scrutinizes like the plan of a campaign. He is known to have knouted the landlord of a country tavern for using lard instead of butter in a dish of cauliflowers, and once he nearly broke the heart of his favorite cook by degrading him to the rank of dish-washer for a similar offense. "Crying and whining will not mend the matter, sir," he told the tearful penitent; "if you had assassinated your gray-haired father, I might call it a perfectly natural act: but that you combine raisins and pork in the same ragout, you must ask your God to pardon you—I can not!" At a banquet in Vienna he was able to indicate the native country of six different kinds of pheasants, but once created a sensation at his hotel by upsetting his chair and leaving the *table-d'hôte* in a towering passion—they had employed hartshorn instead of yeast in the preparation of a certain variety of sponge-cake!

Berlin has its Jockey Club and a "Hof-Restauration," and in elaborate *soupers* can dispute the prestige of St. Petersburg, but Vienna is too gross in its tastes to deserve a place in this list, though to a Hungarian palate its *gulash* (a ragout of broiled mutton) and *Kaiser-suppen* take rank with nectar and ambrosia. Quantity is prized more than quality here, as well as in other parts of southern Germany or in Bohemia, where forty men of a Prussian regiment could successively impersonate a Bohemian burgher before anything wrong was suspected. During the last occupation of Prague by the North-German troops, the legend runs, there was a grand masked ball at the opera-house, in the lower story of which a regiment of Prussian dragoons had been quartered. Somehow or other the soldiers got possession of a *domino* or complete masquerade suit, representing a fat burgomaster in his official toggery. An adventurous private donned the suit and gained admittance to the *superas auras* of the ballroom, and so on to the refreshment-hall, where his enterprise was rewarded by all the luxuries of the Bohemian season. His return to the guard-room with the tale of triumph caused a bonanza sensation, but discipline prevailed, and the regiment was organized into ten-minute reliefs, who in quick succession stormed the works and performed feats of gastronomic daring which soon drew a circle of admirers around the refreshment-table. In and

out rushed the black domino, returning like Antæus with ever-renewed strength, it seemed, from a contact with mother earth. The burghers of Prague looked on, wondered, admired, and finally broke out into enthusiastic applause—they began to comprehend ; it was the consistent, most natural and appropriate acting out of the part which the domino required—the character *rôle* of a fat burgomaster who alternates his official duties with short calls at a lunch-table—and only the fortieth call suggested superhuman powers and an investigation of the mystery.

North America, with all its strawberry short-cakes, clam-bakes, and railroad restaurants, is perhaps, after all, the land blessed with the most natural diet. Healthy food, which is the not-often-used privilege of the rich in Europe, abounds on the table of the poor farmer here. Our five or six largest cities emulate the vice-centers of the Old World, and have not learned yet to sin with grace and long impunity ; but the populations of our glorious rural districts, in the valleys of New England, on the Western table-lands, and in the paradise of the Alleghanies, live more faithful to nature than any white men since the days of Cincinnatus, in the golden age of Italy, and in consequence are healthier and healthier-looking than any contemporary race, the peasantry of the Tyrol and the Swiss highlands alone excepted. There we meet our physical superiors ; but our inferiority is not hopeless, and if we would just fry a little less and cook more, and substitute milk for coffee, Virginia and Vermont would soon turn out boys to match the prettiest Gemsenjäger of the Alpenland.

Hoeing corn and wood-chopping make a hoecake with bacon or a dish of brown beans more palatable than all the *piquanteries* of the Palais Royal ; and even the hog and hominy of the poor tar-heel squatter are preferable to the Irish potato-mess or the cabbage and quass diet of Panslavonia. Exercise in open air as an aid to eupeptic beatitude ranks above all the " old reliable correctives " from the Paracelsian quintessence to Hostetter's bitters. A Persian satrap asked the Spartan ambassador for the receipt of the famous black broth of Lycurgus, but confessed himself unable to relish it without extra spices. " The spices you lack," remarked his guest, "are Spartan gymnastics and a bath in Eurotas."

In Texas, Arkansas, and the Southwestern Territories, we may find habits primitive enough to suit even a Thoreau or an admirer of the patriarchal ages. Abraham treated his angels to a *souper-dinatoire* of roast veal, barley-bread, and milk—more than the Arkansas traveler could count upon at the end of his day's journey. But the air of the prairies, Rocky Mountain adventures, or the vicissitudes of a North Carolina State road can make the homely symposion of a log-cabin as sweet as an evening with Philemon and Baucis.

It has been remarked that the yearning of homesickness is never produced by the recollection of city luxuries, but of rural diet and

habits, and lonely scenery. I am often reminded of an honest mountaineer from western North Carolina who had found a position in the land-office of his State capital. After a session of the State Legislature he was standing among the spectators that always attend the arrival or departure of a Southern railway-train. "Look there, Harry!" said his companion, "there are those representatives of yours again, going to take the cars back to Marion, I guess. Don't they make you feel like taking an up-train yourself sometimes?" "Well, sir," groaned Harry, "I can stand those delegates tolerably enough, but I tell you, if I hear them cry out huckleberries in the morning, it makes me feel like jumping out of bed and starting for home, sweet home, with my shirt-tails flying!"

"Alas," sighs Montaigne, "for my own native hills, and a strawberry-patch, *autour duquel mon âme n'a jamais cessé d'errer!*" May they flourish, the strawberries and huckleberries and the Texas pecans, the peanuts, chestnuts, and maple-trees, and the Chickasaw plums, may they be blessed! Also all johnny-cakes, corn-dodgers, and Tyrolese dumplings, and raspberry puddings, that ever restored health to a stranger or confirmed it to a native! "And above all," says Andreas Hofer in his last address to his countrymen, "beware lest they smuggle in the pottage of Esau with other luxuries of the lowlands; and let your motto be, 'Rye-bread and freedom!'"

BODILY CONDITIONS AS RELATED TO MENTAL STATES.*

By CHARLES FAYETTE TAYLOR, M. D.

WHATEVER that thing, fact, function, or idea which we call mind may be, or whether the brain, as is generally believed, is or is not its sole organ of manifestation, it is universally admitted that varying bodily conditions are accompanied by related variations of mental states. Aphasia, insanity, imbecility, are so often found accompanied by certain definite pathological alterations in the brain-substance that they are generally held to be symptomatic of such local changes. So, also, though in a more general way, melancholia and depression, as well as exaltations and excitements of the mind, are known to depend largely on corresponding general bodily conditions of retarded or accelerated physiological processes.

It is also held, though in a less definite manner, that the health of the body may be affected, beneficially or injuriously, by certain states

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of the mind, as of hope or despondency. Or, more in detail, medical men have observed that certain mental states affect certain functions in certain definite ways. As, for instance, sudden anxiety, as of the non-arrival of a friend when expected, may cause an increase of the peristaltic action, while prolonged anxiety is apt to cause the contrary effect. Joy over good news or at the return of long-absent friends diminishes gastric secretion and causes loss of appetite. The feeble hold on life of the suicidal, and the surprising recoveries from serious diseases and after apparently fatal injuries, in persons whose mental characteristics are hopefulness and determination, are often-recurring facts, familiar to all.

The nature of what we call mind and its relation to the functions of the body is a very wide field of inquiry—too wide, indeed, for our present consideration. But having had unusually favorable opportunities for observing certain phases of psycho-biological relations, I ask your attention while I present some studies which may help us, possibly, to arrive at more practical results, through more satisfactory explanations of certain phenomena, than we have hitherto possessed. So, without further preface, I will introduce my subject by giving a striking example of the influence of a simple mental impression as distinguished from and as independent of thought, will, or consciousness in controlling the manifestation of function.

In September, 1876, I received a letter from a prominent physician living in a Western city, saying that he, in connection with two other medical men, had been treating, unsuccessfully, a case of ununited fracture of the left thigh-bone ; and he inquired if I thought I could do or suggest anything which would lead to its union. The result of some correspondence was that, a few weeks afterward, in October, the patient presented himself with his father at my office.

The case was briefly as follows :

Two years before the young man had met with an accident, and had broken his thigh-bone just above the middle. The family doctor proceeded to set it and apply the proper dressings. In due course of time the fracture united, and the patient got about with some shortening of the limb, and walked with perfect facility for one year, when, in crossing the street, he fell and broke the same bone again about four inches, so they told me, below the seat of the former fracture. Neither of the physicians who had attended him on the previous occasion being in the city, a third medical man, a surgeon of national reputation, was called, who proceeded to apply the proper bandages for fracture. After that the three attended the case conjointly, but no union of the fracture could be obtained, they said, though every usual means had been exhausted to secure it. Such, in brief, was the case as it was presented to me. A careful examination revealed two facts. The first was that there was no ununited fracture, and the second was that the bone had not been broken at the second accident. He was a well-grown, finely formed,

intellectual young man of about sixteen, and he came in on a single crutch, with the left or affected limb swinging limp and wholly useless, and when I laid him on his back, and took hold of the leg to examine it, I found it utterly resistless to every motion. The muscles were wasted, soft, and without tonicity, and, there being a large outward bending in the middle of the bone with lapping of more than two inches, it would roll about, when touched, like a crooked stick on the floor, and it was almost impossible to keep it still long enough to make a diagram. The attenuation of the soft parts was so great that the bone was easily examined, and no line of union or the slightest evidence of callus being felt at the seat of the alleged second fracture, and being assured that one of the remarkable things in the case was that there had never been any callus, I concluded that the bone had not been fractured at the last injury. There was no doubt that an unfractured bone had been hastily put in splints, and for a year, and up to that time, three eminent men had been devising and using various splints for securing apposition of a fracture which did not exist. That it did not exist is proved by the fact that three days after his arrival he was walking on that leg.

The explanation of this case is exceedingly simple: he *thought* he had refractured his femur at the second accident. This impression caused him instinctively and quite unconsciously to withhold muscular action in that limb—that is, he did what he ought to have done if the limb had been fractured. It was the completeness of the control over the muscles, the utter restraint of all muscular action, causing the totally relaxed and powerless condition, which was mistaken for a broken bone. Of course, the trouble was purely mental. But it was not a condition of mind of which he was in the slightest degree conscious. He was not aware of the fact that he was restraining the muscles from acting during this long time; so effectually restraining them that all spontaneity was destroyed by a direct and positive effort of the will. He held his limb in a mental vise of such force and persistency that its nutrition was interfered with, and it was wasted to the last degree. And yet he did not know it. There was no shamming. His condition was a great distress to him. He was also at an age when male persons are the least liable to morbid sentiments. At any rate, I could find none in his case. A mere explanation of his condition was not sufficient to enable him to relax his mental hold on the limb. The mental *impression* subordinated his will and the ordinary desire. His treatment consisted in providing situations which would assist him to *let go* of his leg. I caused him to take certain violent exercises with his upper extremities. The intention was to make them so violent that his whole attention would be required for the upper, and there would be none left for the lower extremity. The plan succeeded. Within three days he gave up restraining the limb—let go of it; in fact, spontaneity was restored, and he began to walk; began involuntarily, and

without being conscious of it, as he was not conscious of restraining it at and after the second injury.

In this, as in all such cases, accepting by the patient of the opinion that the power exists, is not sufficient to restore the member to use. It is very important to secure the intelligent coöperation of the patient, and instructing him by careful explanations goes far in assisting to arrange the circumstances which tend to restore the normal condition. But simply to know and understand the mental nature of the case is not enough to establish control, because it is not the intelligence principally which is at fault, but there is a modification of what may be called mental *timbre*, coloring the thoughts and all mental operations, which, in my estimation, is the quality with which we have to deal in this class of phenomena. Dr. Elsberg has used the word *timbre* to indicate the quality of a compound sound, and I use the word in an analogous manner to indicate a certain quality of the mind as a whole, as distinguished from separate mental attributes. Further illustrations will make this quality of the mind perfectly clear, as well as show that it is through this *timbre* that the mind makes its potent impressions on the organism.

A young lady was brought to me six years ago for what was supposed to be paralysis of the left lower extremity. She had lost the use of that limb eighteen months before, and, since that time, she had got about entirely on crutches. I immediately recognized the mental character of the affection, and adopted the following plan in order to differentiate between the conscious and the unconscious volitions: After a preliminary examination the day before, I called at her room while she was lying on the bed. Requesting her to remain lying, I engaged her in conversation with the intention of absorbing her entire interest. In this I so far succeeded that when I put my hand below her right foot and began to force it upward, she only remarked that that was the wrong limb, and immediately returned her attention to the story I was telling. When I had pressed it upward enough to bend the knee, I asked her to stretch it down again, which she did, repeating the movement several times without paying any particular attention to what I was doing. After making several pretty vigorous efforts to straighten the limb against some resistance from my hand below the foot, I quietly seized the foot of the affected side, and thus both feet were carried upward together, coming down together also. After several such movements, I began to feel distinct muscular action in the affected member, and, after it had become somewhat vigorous, I quietly let go my hold on the well foot, after which she continued to draw up and push down the affected limb as vigorously as she had just before done with the well one. I was successful in holding her attention to my story, so that she had at most but a dim consciousness, if any at all, of what I was doing. I then recalled her attention to her lower extremities, and requested her to push the left foot down, after I had pushed it up, but she could not make the slightest motion with it.

I say she *could* not, because, though there was power in the muscles, there was no consciousness of power, and thus there could be no volition.

The plan of securing an unconscious volition is often very useful and sometimes indispensable in determining questions of diagnosis growing out of mental influence over function. The following incident occurred within the last few weeks: A young lady nineteen years old was sent to me from Albany for what was supposed to be partial paralysis of the left foot and ankle. She had been affected during the past three years, and was so far disabled that she could not walk more than a block or two without danger of falling, and she actually did fall very frequently.

The exciting cause, or that which called her attention to her foot, was the alleged slipping of the tendon of the peroneus longus muscle where it passes under the outer ankle-bone. She had no theory, fancy, or any other sentiment regarding her lameness whatever. She simply dropped her toes when walking, and was obliged to lift that limb very high to advance the foot and prevent stumbling. When, in examining her, I asked her to raise the foot, she was unable to do so. The muscles moving the ankle-joint were powerless. She was very simple-minded, and would try to do whatever I asked of her. So, making an excuse to get off her shoes and stockings, and keeping her attention while gradually working myself across the room, I suddenly asked her to come toward me, being careful to keep her eyes on me instead of her feet. The floor is of hard wood, and without covering, except a bear-skin rug in front of where she sat. The hair tickled her feet, and she came to me with toes elevated and walking on her heels. I then called her attention to the fact that she had bent her ankles to keep her bare feet from contact with the floor, and asked her to bend them again while looking at them. But she could not do it. I found means, however, to relieve the mental impression which interfered so effectually with the autonomy of locomotion, consciousness of power in the affected foot was restored, and, after having been lame for three years, she went home, within ten days, in a natural state.

But unconscious mental interference with the muscles is to be seen not only in loss of muscular power. Increased muscular action, simulating muscular spasm, may have a mental cause. This may be illustrated by a case. In the spring of 1864 a lady, about thirty-eight years old, unmarried, presented herself with a lame shoulder. Three weeks before, as she raised her right arm to turn the slats of the shutters, she felt a sharp pain in the shoulder. It may have been due to a somewhat energetic contraction of certain muscular fibers, such as most of us occasionally experience without any impression being left on the mind, but which in her case left a lasting effect.

I did not understand the true mental character of the difficulty, and the consequence was, that I got into a great deal of trouble before I

got through with the case. But it was all the more instructive on account of my ignorance, as will be seen in its relation; so I give the case more in detail than is necessary in most of these illustrations.

I found her with the right shoulder drawn forcibly upward, firmly fixed in that position, and very sensitive to handling. Supposing that it might be a sprain, and not wishing to treat such cases, I recommended her to apply to the late Dr. E. R. Peaslee, which she did. One year from the first visit she reappeared in a very sad plight indeed. I found the shoulder drawn up still higher than before, and so firmly fixed that the elbow could not be removed from the side of the body more than three or four inches. She looked haggard and worn out, and she reported her sufferings as having been and being very intense. The history intervening between the two visits was, that Dr. Peaslee had given her some liniments, and, after a while, seeing that she did not regain the use of her arm, he sent her to a professional "rubber," who had used a great deal of disagreeable, violent, and painful manipulation. Finding herself becoming steadily worse, at the end of a year she had returned to me. I immediately sought Dr. Peaslee, and together we made a new examination. We found the large pectoral muscle shortened and enlarged to twice its natural size, and the arm so firmly bound down that it was with difficulty that she got her clothing on. After several consultations, we resolved to etherize her and endeavor to stretch the shortened muscles. The plan was, to make an apparatus which should hold the muscles we were to stretch, under ether, in an extended position, for a certain length of time, and thus relax them. The operation was accordingly performed, and all the force consistent with safety to the bone was used, but without appreciable effect in relaxing the great pectoral muscle. The operation was therefore abandoned as a failure. We then considered the propriety of dividing the tendon of the great pectoral; but, as that was a novel suggestion, a consultation was called, Dr. A. C. Post, of this city, and the late Dr. Alden March, of Albany, being the surgeons selected.

The lady had come under the influence of ether with difficulty, and was very much prostrated by it; so that it was over one month after the attempted stretching of the muscle before the consultation was held at the lady's house in Brooklyn. The lady was still in bed, but, after explaining the case, she was got up, when, to our utter astonishment, we found the muscles completely relaxed and the arm perfectly free to move in every direction. Exactly three years after these events, this lady's brother called on me one evening, saying that he had just made an appointment with Dr. Peaslee—who was on the eve of starting for Europe—to meet me at his sister's house the next evening for the purpose of operating on her other arm, which had in the mean time, he said, become affected precisely as the right arm had previously been. It had been affected for a year, but his sister had kept the fact to her-

self, and it had only come out when she could conceal it no longer, the arm having become useless. Supposing that, somehow, the first operation had been the cause of the cure, we repaired to the house as requested, and, after Dr. Peaslee had etherized her, I operated by stretching the contracted muscles. I found the shoulder in much the same plight as the other had been three years before, though the muscles were not quite so rigid, and I could overcome them without much difficulty. But the shoulder-joint had been held in an immovable position so long that the articulating surfaces had become united by bands of fibrous adhesions in various places, and the snapping of these adhesions, as they were torn asunder when the arm was moved about in different directions, made reports which could be heard at a considerable distance. But the muscles were completely relaxed by the operation, motion was restored to the joint, and we congratulated ourselves on having made no mistake and having had a successful case this time. Thus she was left—Peaslee going to Europe, and I about my business. Just one month afterward I was requested to visit the lady. I found that she had been prostrated by the anæsthetic as before, but that her arm and shoulder were in exactly the same situation as before the operation. Not the slightest benefit had been experienced from it. The shoulder was drawn up and immovable, the arm was held firmly to the side, and that extremity was entirely helpless and useless.

It was evident that the mystery of the case had not been fathomed, and I requested her to come to my house so that I might study it. To this suggestion she readily assented, and for the next few weeks I was vainly striving to find remedies for a state of things which I could not comprehend, and to locate a disease which had no existence. At the end of a month, and after calling a well-known surgeon to my assistance without avail, I resolved to try another operation by *force brisée*. Laughing-gas was being used in minor operations at that time, and, as ether made her so very sick, I resolved to use the nitrous oxide. This was administered twice with an interval of four days, when the muscles relaxed, motion was restored to the shoulder-joint, and there has been no recurrence of the condition described during the intervening thirteen years. A case precisely similar to the foregoing was brought to me two years later.

Still under the impression that the force used in the former case had, in some mysterious manner, been the means of cure, and concluding that nitrous oxide was the most favorable anæsthetic, I set to work to cure this case according to such views. After seven entirely successful operations there was not the least improvement in my patient, and I concluded that I had again mistaken the case. I kept her under observation several months, attempting various means, experimentally, which were of no avail, when, on a careful review of this and many other similar cases, I at last came to the conclusion that the whole difficulty was mental and only mental. Having settled the question of

diagnosis, I sought an interview with this lady and explained my views to her. In plain language I told her that she was holding the arm down by direct though unconscious volition, and that all she had to do was to let go her mental hold on the muscles controlling the movements of the affected shoulder. At first she was a little startled, but I told her to think of it overnight and tell me in the morning if, with the aid of my explanations and the facts of her own and other cases which I related to her, she would not arrive at the same conclusion. She returned the next day, saying that she was convinced that I was right; that she was sure that, through dread of the pain which she anticipated, if she allowed the shoulder-joint to move, she was holding it by main force. She knew and believed all this, but still she had not the power to relax her mental hold on the muscles of the shoulder. To assist her in this I adopted the following plan: I caused her to recline in an easy position, while I stood behind her and took both her hands, the arms bending at the elbows. I made not the least traction on the hands, but simply held them for the purpose of directing and controlling her attention. My requirement was to raise both arms into the upright position, that is, to extend the arms over the head, but not to raise the right, which was free, any faster than she did the left, which she was holding down in close contact with the body. The object was to cause her to give her attention to and absorb her thoughts and interest in the right and unaffected arm, so as to enable her to relax her hold on the left and affected shoulder. The expedient was successful. She did let go her arm, and within a week she had entirely relaxed the muscles about the left shoulder, and regained complete use and control of the previously rigid joint.

I have seen every joint in the body relaxed or stiffened by mental influence, often disastrously so when no aid came to them—sometimes relaxed and stiffened by turns; but I introduce illustrations from cases where these peculiar manifestations have happened at the shoulder, first because they are typical cases, and secondly because I fancy they might be more likely to escape the possible suggestion that, after all, there might have been some organic lesion involved in the cases. We certainly do have the same mental influences complicating organic diseases of the joints. But my object, at this time, is to exclude such cases as can justly be subject to such an imputation. Of course, after once understanding the true condition of things, it is easy to see that the only influence of the respective operations of *force brisée*, in these cases, was on the patient's mind. In the first case, while she was lying weak and prostrate from the effects of the anæsthetic, she forgot her shoulder and simply let go of it. That was all. In the next operation, three years afterward, on the other shoulder, there was less novelty calculated to engage and keep her attention, and the rupturing of the adhesions which had sprung up in consequence of prolonged loss of motion was sufficient to maintain her interest in the joint, so that her attention failed to be

diverted. But the circumstances attending the operations with the laughing-gas were again calculated to absorb the attention in other directions and thus divert it from the shoulder. The result was the immediate relaxation of the muscles involved in maintaining the shoulder in a fixed position. In the absence of any local disease which could cause local irritation and reflex muscular contraction, this must have been kept up by direct volition. An important evidence of its voluntary character, besides that which is afforded by the prompt relaxation through opposite mental influence, was the immediate and very great improvement in the patient's general health. She was, in fact, completely exhausted by a labor which she was not conscious of doing, but when she ceased this continuous effort she at once improved in strength. The same improvement in the general health, but in an even more marked degree, was manifested in the second case above related.

Adult life is not alone liable to the class of mental influences which we are now discussing. Young persons and even quite small children are frequent subjects for psycho-biological study.

But mental influence over bodily function is exhibited not alone in connection with the muscles in determining their relaxation or rigidity, in certain cases; but what are called bodily sensations are even more dominated by the mental timbre of the individual. We have local and general hyperæsthesias and anæsthesias both as transient and as permanent conditions from this cause. I feel obliged to employ phrases as they are employed in common use, but, strictly speaking, there are no bodily sensations, for all sensation is mental—there is and can be no other. The most that we can strictly say is that we feel in the mind, but refer the cause of such feeling to certain locations in the body. Stick a pin in my flesh, and whether I feel it or not, and how much I may feel it, will depend wholly on the state of my mind. If obscured by an anæsthetic or if asleep, provided the impinging on the nerves is not sufficient to waken me, or even if my attention be very much absorbed, I shall not be conscious of the pricking. On the other hand, if I have been pricked before so that my fears are aroused, or if I am worried or weary or ill, then the pain is many hundred times greater than under the opposite circumstances. We go to a dentist one day when we are in a hurry, and with the mind troubled about some matter. The drilling of his little instrument is agony. We leave and return the next day with plenty of time, and our business settled. The dentist drills still deeper into the same cavity while we sit in comparative comfort.

But not only the same person has different degrees of sensation at different times, according to his mental timbre at the time, but different individuals and different classes of persons feel both pleasures and pains more or less according to their individual or class elevation in the intellectual scale. If a knife were thrust into the flesh, in corresponding locations and to the same depth, in twenty people, no two would feel

the incision to the same degree, and the difference in sensations would be simply the difference of mental constitutions, that is, it would be wholly mental. So of classes. The child of the widow, Bridget Murphy, who lives in a back alley and goes out to work by the day, leaving her children at home with nothing to stimulate the mind, does not feel the same amount of pain from the pressure of an instrument which is applied for disease of the hip-joint, which he has got in falling down stairs, as the child reared among the excitements of a cultivated home, with pictures and toys, the circus and menagerie, dogs and horses, and the society of cultivated adults to stimulate mental activity. While the widow's son can hardly talk at five years old, the other, by aid of French and German nurses, speaks three languages at the same age. But when he falls on the ice and gets hip-disease, his sufferings correspond to his mental rather than to his bodily condition, and his pains, like his pleasures, are as much greater than those of the first-mentioned child as his mind is more active and thus more susceptible. To continue the illustration, the instrument worn by the child intellectually low down may, by the mother's ignorance and neglect, become buried in the flesh, with slight murmur, compared to the distress caused by a crumb of bread or a wrinkle in the linen under the points of pressure in the mentally active child. Mental susceptibility corresponds closely with mental activity, so that so-called bodily sensibility must correspond closely again with mental activity. And we find this to be the case. What is said to be Indian fortitude, when they tear their flesh in some of their rites, is simply brutishness. They do not feel in the same degree that we should under the same circumstances. And, on the other hand, the cultured and æsthetic should comprehend, more than they do, that an increased capacity for painful sensations is the direct result and the constant accompaniment of the refinements of civilization, and that to suffer is inevitable along with the pleasurable emotions, which constitute at once the compensation and the charm of the higher civilized existence.

An illustration or two of the mental production of hyperæsthesia —and it is the same with anæsthesia—will suffice for this part of our subject.

It should be remembered that each case represents a class of cases, and is not simply an isolated and phenomenal instance of a curious manifestation. Many cases of lameness of the ankle-joint are produced by, or, strictly speaking, exist only in, the mind, as, for instance, the following among many others :

An unmarried lady of thirty called on me for advice with reference to a foot and ankle which she had not been able to use during the three and a half years preceding. There was a history of some slight injury, with periods of improvement during the first six months of her lameness, but with a final loss of ability to use it on account of its exceeding painfulness at every attempt to bear her weight upon it, and she had been

for that length of time on crutches. The foot and ankle were very thin, cold, and clammy, and even very gentle manipulation caused considerable pain. I could not make out, from all the history which I could gather from the lady herself, with the help of her sister, who accompanied her, that the so-called injury had been at all serious, and I concluded that what had been supposed a serious injury to the ankle had simply been a circumstance which had established a condition of apprehension in regard to that locality.

A careful examination satisfied me that the lameness was in the mind, referring to the foot and ankle, but without any sufficient injury of the parts referred to to cause lameness. It was therefore the mind rather than the foot and ankle which ought to be treated, and it was the mind which I did treat, with success. There was no excessive fear here, as there is in many cases, but simply pain on using the foot. Of course there was the misapprehension with regard to the nature of the case, and correcting this misapprehension was one important element in treatment. But such correction only put her *en rapport* with her treatment, but did not alter the fact that it *did* hurt to bear weight on the foot. In such cases it is important to give some time for the emotions to adjust themselves to what the intelligence accepts on the subject. In the mean time something was given her to do, some uses of the foot which would fall far short of attaining the point of pressure or motion which her experience had shown would or might be painful; that is, she was required to never approach the point where she had been accustomed to expect to be hurt. Thus the element of expectancy was gradually lessened, and finally eliminated entirely, so that in a few weeks she could walk as well as ever. This was twelve years ago. She has never had a relapse, and is perfectly well to-day. This is one of the classes of cases out of which the so-called "bone-setters" make so much capital.

The foot, ankle, knee, and hip joints are all frequently referred to when there is no organic affection at the point indicated by the mental impression, and I might go on almost indefinitely relating instances, if time permitted. But it may be sufficient to indicate the frequency of disturbed psycho-biological relations to say that I estimate that not less than one half of all cases applying to me for relief from joint affections belong to the class under discussion.

Before leaving this aspect of the subject I think I ought to mention the case of a little girl living in Williamsburgh, who, when she was about three years old, saw a very lame child in the street one day, a patient of mine, and when she returned home her family were surprised to find her lame. The patient the child saw was affected by paralysis, but, curiously enough, the child's lameness simulated disease of the hip-joint. Paralysis could not be well imitated. I was consulted some two years after the first appearance of the lameness, and her attending physician, the late Dr. Brady, of Williamsburgh, gave me the history of

her case and the treatment which he had pursued. I had pronounced the lameness mental before I knew of the circumstance which this physician related to me. A surgeon celebrated as a joint-doctor was consulted soon after the lameness was discovered, who pronounced it a case of hip-joint disease. She was treated by confinement and extension, the weight and pulley being used for the latter purpose. The limb, which had been drawn up very much, quickly came down to its natural position, and, after three months of this treatment, finding everything right, no pain on motion, the limb straight out, etc., the case was considered cured, and the doctor asked some of his friends, brother physicians, to see her put on to her feet and attest the remarkable cure. So, after they were assembled, the bandages were taken off and she was put on the floor and told to walk across the room. "You can imagine my surprise and disgust," said he, in telling me the story, "to see her go across the room with the leg drawn up precisely as it was before, and without any change whatever in the amount of deformity or her manner of walking." This child has been brought to me from time to time during the past twelve years, but I have always refused to accept the case as one of disease of the hip-joint. Just one year ago I examined her for the last time. She was then fourteen years old, and anxious to get her leg down. It had been drawn up since she was three years of age. The hip-joint was in perfect condition, and the only reason why she couldn't walk as other persons do was the shortening of the flexor muscles due to the persistent, drawn-up position. The growth had been retarded somewhat, because it had been used less forcibly. But no injury had been done to the hip-joint.

This child was so young when the affection first appeared that it was never made out what were the particular sensations which influenced the volition in the way they did.

It is necessarily more easy to get demonstrations and illustrations of the various influences of the mind over the sensations and the voluntary muscular actions than of the involuntary processes of life. But it must not be supposed that sensation and motion are alone influenced or dominated, as the case may be, by mental states, for it is possible that involuntary processes are even more under the same influence. To a certain and very positive extent they certainly are. To merely mention the phenomena of blushing, pallor, palpitation, shivering, sea-sickness, etc., suggests effects on the involuntary functions which are so common as to be almost overlooked in enumerations of kindred examples. But that the influence of certain sentiments on certain involuntary functions is very potent and positive is well illustrated in the following case:

A lady friend of mine had for some years been speaking to me, as I met her socially from time to time, with regard to the condition of one of her daughters. Otherwise a healthy young lady of about twenty-four years of age, she had had, all her adult life, the one trouble of inveter-

ate constipation. The most powerful medicines in exceptionally large doses failed to produce more than the most meager effects, until at last her condition became alarming. At this juncture they put her under my direct professional care. But nothing that I could do seemed to have the slightest effect on her in ameliorating her condition. As she lived in my family, I had every opportunity to observe her, and after a while my attention was attracted to the fact that, in making my inquiries as to how she felt, she never seemed to know anything about it. In fact, she would deny having any sensations of any kind whatever. I would sometimes see her, while in the family circle, put her hand to her back or to some other part of her body, acting as if she had a sharp pain there. But, even when I made immediate inquiries, she would invariably deny that she had felt any pain whatever. At length circumstances supervened which made me positive that conditions existed which, in any ordinary person, would cause the sensation of pain. But she denied any such sensation. At last, after three months of fruitless effort to relieve her, I made up my mind that this was a case the reverse of the more common result of civilized existence. Her mind, instead of being too firmly centered on some organ or function, was too much withdrawn from the ordinary phenomena connected with existence. In a word, she was suffering from not perceiving, and thus not knowing and heeding, the natural monitions. Having come to a correct diagnosis of the case, I explained very carefully all the facts, and gave her minute directions calculated to assist her in fixing and keeping her attention upon her bodily functions till they should respond to the mental stimulus thus restored to them. The result was that, within two days, by the mere change of sentiment regarding a certain function, that function, which during not less than fifteen years had been wellnigh suspended, was immediately stimulated to full activity. I impressed her mind with the belief that certain results would happen by following the directions which I gave her for the purpose. This was eleven years ago, and this lady told me only a few months ago that she has remained in perfect health, so far as the function in question is concerned, during the whole time.

Heretofore I have adduced such cases only as were clearly uncomplicated with organic disease, and generally where there had been some exciting cause to determine the special location of the mental interference.

When I say "exciting cause," I mean, of course, some circumstance or event which is calculated to fix the attention and make a mental impression. But, in the majority of instances, no such "exciting cause" is traceable. It generally simply happens that the subject finds himself with certain abridgments or apparent exaltations of the perturbed function, without being able to trace the event which determined the character and location of the mental influence. It is highly probable that in most cases there have been circumstances which have

led directly to the result as seen, but which have made no impression on the patient's memory. Still, it seems probable also that there may be mental influences excessively manifested over particular organs and functions, which are determined by purely subjective causes and without the intervention of external circumstance. Be that as it may, it seems to be necessary that there should be a certain preparation—a sort of condition precedent—in the mind which makes it liable to abnormal manifestations. Mental influence over bodily function is in itself a constant and therefore a normal condition of existence. But one of the products of civilization is to exalt the mental into a too preponderating influence. In that exaltation the mind easily becomes hyper-susceptible. It takes on, with abnormal facility, a timbre of which it is not itself conscious, but which tends to modify biological relations in the way, among others, which I have to a certain extent illustrated in the preceding pages.

Now, there are various circumstances which favor modifications of psycho-biological relations, but which do not themselves directly cause them. Among those most frequently coming under professional recognition, hysteria may be instanced as a potent influence ; but, in the light of the facts in my experience, it is incorrect to speak of the hysterical foot or the hysterical stomach or knee. We have the phenomena exhibited in both sexes, in children of tender years and in men and women in advanced life. Hysteria, or, more properly, imperfect sexual hygiene in both male and female, by perturbing the system, does produce a condition favoring modifications of the mental states ; but the phenomena under consideration are not themselves hysterical. Any thing or any influence—and they are many—which can increase the mental tension and impressionability beyond a certain normal standard, will produce a modification of the timbre such as we see exemplified in so many instances. Besides the peculiar cases given as illustrations, there is a large class of what are called "simulated diseases," persons with local sensations or pains which do not arise from or represent corresponding local diseases. These can not have even a passing allusion here. Time also prevents me from entering into a discussion of the important subject of mental influence on actual disease, even if that aspect of my subject did not more properly belong to the medical department of biology. Suffice it here to say that, as must be inferred from the facts and arguments already adduced, no system of therapeutics can be complete which does not embrace the design of controlling psycho-biological relations in general, and with reference to chronic disease especially.

From the foregoing presentation, several important and practical deductions may be drawn :

1. Mental culture, while it brings more physical pleasure, brings also increased bodily susceptibility.

2. Pain, at least that which we are now considering, is but an in-

creased degree of sensation, which, in ordinary measure, is either not noticed or pleasurable.

3. Sensations called pains should not be mistaken for, confounded with, or be considered the measure of disease, even when accompanied by it.

4. All sensations, including unpleasant sensations or pains, represent mental qualities only, and these always correspond, no matter what the exciting cause, with the capacity of the mind to be impressed; that is, with its rapidity and force of action.

Lastly, the individual is generally incapable of correctly estimating the subjective value of his own sensations, whatever character they may assume.

Intimately connected with, and in fact growing out of, the subject of the influence of mental timbre over the functions of the body, are many interesting questions of mental ethics which, it seems to me, ought to be studied from a somewhat different point of view than that from which they are commonly regarded.

As we have seen that bodily functions may be profoundly modified under unconscious mental influence, so it will be found, when carefully analyzed, that the product of the mental operations themselves may be likewise modified, under peculiar subjective influences, without arousing the consciousness. In a word, the mind may be in a condition of what we may, illustratively, call *mental allotropism*, during which the laws ordinarily controlling mental operations seem to be reversed, with corresponding products of intellection.

A case in point is now attracting altogether more attention than it deserves, or would receive, if properly understood. It is stated in the newspapers that there is a young lady living in our neighboring city of Brooklyn who, among other surprising things which she does or omits to do, has not eaten any food or taken any nourishment during the past nine years. It is claimed, on the one hand, that this lady is a perfectly truthful person, with a highly endowed moral sense, intelligent, kind, benevolent, and shrinking from notoriety, and that her statements ought to be taken as conclusive in regard to the facts. The absence of any motive for propagating an unprofitable, ridiculous falsehood is held as confirmatory of her allegations. On the other hand, it is as stoutly maintained that she is an arrant impostor, whose sole purpose is to acquire a transient notoriety; and the non-acceptance of various tests, proposed to substantiate or disprove her statements, is adduced as evidence of the fraud attempted. Now I think we shall see that, in the light of inferences from what has preceded, neither party to this controversy is wholly right or altogether wrong. While it can not for a moment be admitted that a person can live nine years, or any number of years, without food, yet it would be contrary to related facts, and illogical, to assume that she intends to deceive. It is quite within the possibilities that this lady believes that she does not eat. And yet she

must necessarily take food. There can be no doubt of that. Let us draw a few parallels, and see how easily such cases are explained by very ordinary and accepted facts. Every physician has had cases of persons who asserted that they did not sleep at all for long seasons at a time, while the fact was that such persons did actually sleep a good deal, as proved by being seen asleep, and by the fact that they did not suffer in health, as they must have done if sleep had been entirely absent. But these persons, while asserting that which was not true concerning an important matter, did not intend to falsify. They simply stated what they believed to be true. Their mental condition was such that they did not feel the impression which sleep ordinarily makes on the consciousness. They slept, but, having no impression of sleep, they asserted that they did not sleep. They could not, with the only evidence which they possessed, the absence of any mental impression of having slept, assert otherwise. There are other persons who, under certain states of mind, say that they eat almost nothing at all—"not enough to keep a bird alive"—while, as a matter of fact, they do eat very well, sometimes even heartily. We see them eat enough to maintain them well nourished, and yet they assert that they do not eat enough for the bodily requirements. Again, the difficulty lies, not in the fact of eating, nor in any desire to falsify, but in the fact that, in their peculiar mental condition, their eating, though seen by others and by themselves, makes no impression on their minds. They state, not what is true, but what they *feel* to be true. To recur to the more typical class:

A lady, who was at once the daughter of one physician and the sister of another, lost the use of one limb soon after a slight attack of sore-throat. She got about on crutches for nearly a year, and when summer came she went into the country, where she grew stout and was in perfect bodily health, joyfully anticipating a speedy return to her home in the city with restored powers. But suddenly the other limb gave out, and she was brought helpless back. After I had examined her I knew that she had all the power in her limbs which she had ever had, but that did not make me think that she was intending to deceive me when she asserted that she had no power to stand. Her statement was contrary to the fact, but she had to express that which she *felt* to be the fact. The parallel goes even further than this.

This person did use her limbs more or less in certain ways, and under certain circumstances. But that fact made no impression on her consciousness, as against the stronger impression of entire want of power in her limbs. And so it is in all of the cases of perverted and abnormal mental timbre, when this condition has passed a certain boundary. The words spoken and the things done are dominated by the paramount influence on, and take their quality and coloring from, the predominating mental state of the subjects of it.

Nevertheless, while the mental timbre is an independent condition,

it does not prevent the introduction of moral qualities also. A person may lose the use of a member, for instance, through loss of consciousness of power in that member, and at the same time she may have so much pleasure in the sympathy which the disability excites in those around her as to prefer to be lame or bedridden. Confinement, from any cause, is more apt to be demoralizing than elevating, at the best, and it is not strange that a certain number of bedridden cases should, more through the ignorance and want of tact of those around them than original desire to deceive, form the habit of, first, making the most of their infirmities to increase sympathy, and, finally, come to exaggerate and to falsify; thus they pave the way to becoming the instruments of their own and others' craving to be considered phenomenal. And it may well be, and circumstances seem to establish, that the Brooklyn case alluded to has arrived at that point now. I only insist that it is not logically necessary, in similar cases, to assume intentional deception from the beginning, nor, in many cases, at any time can this be rightfully asserted.

It will be observed that I have not used the word "imagination" in connection with the phenomena under consideration. I have not used that term, because it does not apply to the facts. Imagination is an attribute of the mind, an important but wholly distinct mental faculty. But it is not the whole mind, neither does it represent a special condition of the mind. The imagination is often given full play in many of these cases, and undoubtedly assists in producing that mental state which ultimately ends in mental allotropism. But, however conspicuous the imagination may be in such a case, its only importance consists in being one of the many factors tending to produce a certain definite result, which, when reached, is not imagination nor the direct product of the imagination. I speak of this because I think a great deal of harm has been done by the use of this word. It is employed, generally, as if the use of it carried some explanation, and it is understood by the subjects as casting some imputation. Besides, abnormal mental timbre, productive of positive effects on the organism, is quite as apt to be manifested in certain wholly unimaginative persons as in the imaginative. The most marked cases which have come under my observation have been those of persons whose characteristics have been strong common sense and self-forgetfulness.

NEW GUINEA AND ITS INHABITANTS.

By ALFRED RUSSEL WALLACE.

II.

THE houses of the New Guinea people are somewhat different in different localities, but the most general type is that found at Dorey Harbor. There is here a considerable village of large houses built on piles in the water in the usual Malay style, and houses similarly raised on posts (but loftier) are found on the hills some miles inland. Each of these houses is large and accommodates several families, and they are connected by continuous platforms of poles and bamboos, often so uneven and shaky that a European can with difficulty walk on them. A considerable space separates this platform from the shore, with which, however, it is connected by narrow bridges formed of one or two bamboos, supported on posts, and capable of being easily removed. A larger building has the posts carved into the rude forms of men and women, and is supposed to be a temple or council-house. This village is probably very like the pile villages of the stone age, whose remains have been found in the lakes of Switzerland and other countries. Similar houses are found in the Aru and Ké Islands, in Waigiou, and on the southwest coast; and they are also common on the southeast coast, sometimes standing in the water, sometimes on the beach above high-water mark. These houses are often a hundred feet long, and sometimes much more, and are occupied by ten or twenty families. On the Fly River similar large houses occur, but only raised a foot or two above the ground; while at the mouth of the Utanata River, on the southwest coast, a large low house was found a hundred feet long, and only six feet wide, with nineteen low doors; but this was evidently only a temporary seaside habitation of a tribe who had their permanent dwellings inland.

Finding these large houses, raised on posts or piles and common to many families, to prevail from one end of New Guinea to the other, both on the coast and inland, we are led to conclude that those described by Dr. Miklucho Maclay at Astrolabe Bay, on the northeast coast, are exceptional, and indicate the presence of some foreign element. The houses of the people among whom he lived were not raised on posts, and had very low walls, so that the somewhat arched roofs appeared to rise at once from the ground. They were of small dimensions, and seem to correspond pretty closely to those of the Admiralty Islands, New Britain, and New Ireland; so that this part of the coast of New Guinea has probably been colonized from some of the adjacent islands, a view supported by the fact that these people do not use bows and arrows, so general among all the true Papuans, and by other peculiari-

ties. It is somewhat unfortunate that the only scientific man who has resided alone among these people for more than a year, for the express purpose of studying them exhaustively, should have hit upon a place where the natives are probably not true indigenes but an intruding colony, although perhaps long settled in the country. Dr. Miklucho Maclay will no doubt be quoted as the greatest living authority on the Papuans of New Guinea; and it is therefore very important to call attention to the fact that the people he so carefully studied are not typical of the race, and may not even be Papuans at all in the restricted sense in which it is usually applied to the main body of the aborigines of New Guinea.

The Papuans, as well as all the tribes of dark, frizzly-haired Melanesians, make pottery for cooking, thus differing from all the brown Polynesian tribes of the Pacific, none of whom are acquainted with this art. Of course the actual seat of manufacture will be dependent on the presence of suitable materials; but those who do not make it themselves obtain it by barter, so that earthenware cooking-vessels appear to be in general use all over the island. Cups and spoons are made out of shells or cocoanuts, while wooden bowls of various sizes, wooden mortars for husking maize or rice, wooden stools used as pillows, and many other articles, are cut out and ornamented with great skill. A variety of boxes are made of the split leaf-stalks of the sago palm, pegged together and covered with pandanus-leaves, often neatly plaited and stained of different colors, so as to form elegant patterns. A variety of mats, bags, and cordage, are made with the usual skill of savage people; and their canoes are often of large size and beautifully constructed, with high-peaked ends ornamented with carvings, and adorned with plumes of feathers.

The weapons chiefly used are spears of various kinds, wooden swords and clubs, and bows and arrows; the latter being almost universal among the true Papuans and most of the allied frizzly-haired races, while the Polynesians seem never to possess it as an indigenous weapon. It is very singular that neither the Australians, the Polynesians, nor the Malays should be acquainted with this weapon, while in all the great continents it is of unknown antiquity, and is still largely used in America, Asia, and Africa. Peschel, indeed, attempts to show that the Polynesians have only ceased to use it on account of the absence of game in their islands; but mammalia are almost equally scarce in the New Hebrides, where it is in constant use even in the smallest islands; while in Australia, where they abound, and where it would be a most useful weapon, it is totally unknown. We must therefore hold that the use of the bow and arrow by the Papuans is an important ethnological feature, distinguishing them from all the peoples by whom they are immediately surrounded, and connecting them, as do their physical peculiarities, with an ancient widespread negroid type.

In their knowledge and practice of agriculture the Papuans show

themselves to be far superior to the Australians, and fully the equals of the Polynesian races. They grow cocoanuts and bread-fruit, and cultivate various kinds of yam, sweet potato, bananas, and sugar-cane. Though possessing, for the most part, only stone axes, they clear the forest to make their plantations, which they carefully fence round to keep out the wild pigs. Looking at these clearings, at their houses, their canoes, their implements, weapons, and ornaments often elaborately carved, we must, as Dr. Maclay remarks, be struck with astonishment at the great patience and skill displayed by these savages. Their chief implement, the axe, consists of a hard gray, green, or white stone, made smooth and sharp by long grinding and polishing. A piece of the stem of a tree which has a branch passing off at an angle, something like the figure 7, is hewed off, and upon the branch, which has been cut off short and shaven at the top, the stone is laid horizontally, and bound fast with split rattans or tough bark. Such an instrument requires to be used with great skill, only to be attained by practice, or the stone will be broken without producing any result. These savages can, however, with a stone axe having a cutting edge only two inches broad, fell a tree-trunk of twenty inches diameter, or carve really fine figures on a post or spear. Each adult man possesses one such axe, but in every village there are usually one or two larger two-handed axes, which are about three inches broad. These are considered exceedingly valuable, and are only used for cutting large trees for canoes or other important work. Fragments of flint and shells are used for finishing carved work and cutting the ornamental patterns on bamboo boxes, as well as for making combs, spoons, arrows, and other small articles. For cutting meat and vegetables a kind of chisel of bone and knives of bamboo are made use of. On the northwest and southwest coasts, where the people have long been in communication with Malay traders, they have iron tools and weapons, and cultivate also maize and a little rice and millet, and have the papaya as an additional fruit and vegetable ; and they also grow tobacco, of which they make huge cigars. At Dorey they have learned to work iron, and make swords and choppers as well as iron points to their arrows and spears.

The daily food of these people consists of some of the vegetables already named, of which they have a pretty constant supply, together with fruits, fish, and occasionally the flesh of the wild pig, the cuscus, or of birds caught in snares or shot with arrows. They also eat shellfish, lizards, and almost every kind of large insect, especially beetles and their larvæ, which are eaten either raw or cooked. Having no salt, they mix sea-water with that in which they cook their food, and this is so highly esteemed that the people of the hills carry away bamboos full of salt-water whenever they visit the coast.

The plantations are usually made at some distance inland for safety, and, after the ground is cleared and fenced by the men, the cultivation is left almost wholly to the women, who go every day to weed and

bring home some of the produce for the evening's meal. They have throughout the year a succession of fruits and vegetables either wild or cultivated, and are thus never half-starved like the Australians. On the whole the women are well treated and have much liberty, though they are considered as inferiors, and do not take their meals with the men. The children are well attended to, and the fathers seem very fond of their boys, and often take them when very young on their fishing or hunting excursions.

As in the case of most other savages, we have very different and conflicting accounts of the character of the Papuans. Mr. Windsor Earl well remarks, that whenever civilized man is brought into *friendly* communication with savages, the disgust which naturally arises from the first glance at a state of society so obnoxious to his sense of propriety, disappears before a closer acquaintance, and he learns to regard their little delinquencies as he would those of children; while their kindliness of disposition and natural good qualities begin to be recognized. Thus many writers make highly favorable statements respecting the Papuan character and disposition; while those whose communications with them have been of a *hostile* nature are so impressed with their savage cunning and ferocity, and the wild-beast-like nature of their attacks, that they will not recognize in them any feelings in common with more civilized races.

Many of the early voyagers record nothing but hostility or treacherous murders on the part of the Papuans. Their visits were, however, chiefly on the northwest and southwest coasts, which the Malays have long been accustomed to visit not only for commerce but to capture slaves. This having become a regular trade, some of the more warlike coast tribes, especially those of Onin in McCluer's Inlet, have been accustomed to attack the villages of other tribes, and to capture their inhabitants, in order to sell the women and children to the Malays. It is not therefore surprising that unknown armed visitors to these coasts should be treated as enemies to be resisted and if possible exterminated. Even Europeans have sometimes increased this feeling of enmity through ignorance of native habits and customs. Cocoanut-trees have been cut down to obtain the fruit, apparently under the impression that they grew wild and were so abundant as to be of little value; whereas every tree is considered as private property, as they supply an important article of food, and are even more valued than the choicest fruit-trees among ourselves. Thus Schouten, in 1616, sent a boat well armed to bring cocoanuts from a grove of trees near the shore, but the natives attacked the Europeans, wounded sixteen of them, and forced them to retire. Commodore Roggewen, in 1722, cut down cocoanut-trees on the island of Moa on the north coast, which, of course, brought on an attack. At other times houses have been entered in the absence of their owners, a great offense in the eyes of all savage people, and at once stamping the intruder as an enemy.

On the other hand, Lieutenant Bruijn Kops, who visited the northwest coast of New Guinea in 1850, gives the following account of the inhabitants of Dorey:

Their manners and customs are much less barbarous than might be expected. On the contrary, they give evidence of a mild disposition, of an inclination to right and justice, and strong moral principles. Theft is considered by them as a grave offense, and is of very rare occurrence. They have no fastenings to their houses, yet seldom or never is anything stolen. Although they were on board our ship or alongside during whole days, we never missed anything. Yet they are distrustful of strangers until they become acquainted with them, as we experienced. This is probably less, however, a trait of their character than the result of intercourse with strangers who perhaps had frequently tried to cheat them. The men, it is true, came on board from the time of our arrival, but they were very cautious in letting any of the things they brought for sale out of their hands. The women were at first very fearful, and fled on all sides when they saw us, leaving behind what they might be carrying; but at length when they found they had no injury to dread from us they became more familiar. Finally, they approached without being invited, but remained timid. The children very soon became accustomed to us, and followed us everywhere.

Respect for the aged, love for their children, and fidelity to their wives, are traits which reflect honor on their disposition. Chastity is held in high regard, and is a virtue that is seldom transgressed by them. A man can only have one wife, and is bound to her for life. Concubinage is not permitted. Adultery is unknown among them. They are generally very fond of strong drink, but, although they go to excess in this, I could not learn that they prepared any fermented liquor, not even *sago-weer* or *tuak* (palm-wine). Kidnapping is general in these countries, and is followed as a branch of trade, so that there is no dishonor attached to it. The captives are treated well, are exchanged if there are any of theirs in the enemy's hands, or released on payment of a ransom, as was the case in Europe in the middle ages.

My own experience of the Papuans at Dorey, in 1858, agrees with this account; and as I lived there for four months with only four Malay servants, going daily unarmed into the forest to collect insects, I was completely in their power had they wished to attack me. A remarkable proof of their honesty occurred to me at the island of Waigiou, where a man who had received payment in advance for red birds of paradise brought back the money, represented by an axe, when after trying for several weeks he had failed to catch any. Another, who had received payment for six birds, brought me in the fifth two days before I was to leave the island, and immediately started off for the forest to seek another. Of course I never expected to see him again, but, when my boat was loaded, and we were just on the point of starting, he came running down to the beach holding up a bird, which he handed to me, saying with evident satisfaction, "Now I owe you nothing." My assistant, Mr. Allen, venturing along among the mountaineers of the northwest peninsula, found them peaceable and good-natured. Drs. Meyer and Beccari and Signor d'Albertis, penetrating inland beyond Dorey, were never attacked or seriously opposed; and Dr. Miklucho

Maclay suddenly appearing at Astrolabe Bay, among people who seem never to have had any communication with Europeans, soon established friendly relations with them, although subject to great trials of temper and courage at the outset.

His experience with them is very instructive. They appeared at first distrustful and suspicious of his intentions, as well they might be. Sometimes they left him quite alone for days together, or kept him prisoner in the little hut he had had built for himself, or tried to frighten him by shooting arrows close to his head and neck, and pressing their spears against his teeth till they made him open his mouth. Finding, however, that he bore all these annoyances good-humoredly, and, as a medical man, took every opportunity of doing them services, they concluded he was a good spirit, a man from the moon, and thenceforth paid him great respect, and allowed him to go about pretty much as he pleased. This reminds us of the experience of the Challenger at Humboldt Bay, where it was decided not to stay, because some of the natives similarly drew their bows at the officers when away in boats. This was no doubt nervous work for the person threatened, but it was only a threat. Savages do not commence a real attack in that theatrical way, and, if they had been met with coolness and their threats been laughed at or treated with contempt, such demonstrations would soon have ceased. Of course it requires very exceptional courage and temper, not possessed by one man in a thousand, to do this; but the fact should be remembered that in many parts of the world such attempts to frighten Europeans have been adopted, but have never resulted in anything serious. Had the Papuans really wanted to rob and murder, they would have enticed the Challenger people on shore, where they would have had them completely at their mercy, whereas those who did go on shore were very civilly treated.

One of the most curious features noticed by Dr. Miklucho Maclay was the apparent absence of trade or barter among the people of Astrolabe Bay. They exchange presents, however, when different tribes visit each other, somewhat as among the New-Zealanders, each party giving the other what they have to spare; but no one article seems ever to be exchanged for another of supposed equivalent value. On the whole, the Russian doctor seems to have found these people industrious, good-natured, and tolerably cleanly, living orderly lives, and conforming themselves strictly to the laws and customs which to them determine what is right.

Captain Moresby, Signor d'Albertis, Mr. O. C. Stone, and the missionaries who have recently explored the southeastern extremity of New Guinea, have been greatly struck by the apparently quite distinct races they have found there. As far eastward as the head of the gulf of Papua (on the east side of Torres Straits) the typical Papuans prevail, the natives of the Katow River being described as nearly black,

with Jewish noses, and woolly hair, using bows and arrows, and living in houses a hundred feet long elevated on posts, in all respects exactly agreeing with the prevalent type in the western portion of the island. But farther east, about Redscar Bay and Port Moresby, and thence to East Cape, the people are lighter in color, less warlike, and more intelligent, with more regular European features, neither making bows nor (except rarely) pottery, and practicing true tattooing by punctures—all distinctly Polynesian characteristics. When to this we add that their language contains a large Polynesian element, it is not surprising that these people have been described as a totally distinct race, and have been termed Malays or Malayo-Polynesians. We fortunately possess several independent accounts of these tribes, and are thus able to form a tolerably good idea of their true characters.

Captain Moresby, speaking of the inhabitants of that large portion of the eastern peninsula of New Guinea discovered and surveyed by him, says:

> This race is distinctly Malayan; but differs from the pure Malay, being *smaller in stature*, coarser in feature, *thicker-lipped*, with *less hair on the face*, being in fact almost beardless. The hair on the head is also *more frizzled*, though this may result from a different dressing. These men have high cheekbones like the pure Malay; their noses are inclined to be aquiline and sometimes very well formed. Among them are met many men with light hair, and what struck us as a peculiarly *Jewish cast of features*. They rise to a height of from five feet four inches to five feet eight inches, are sinewy though not muscular, *slight, graceful, and cat-like* in the pliability of their bodies.*

This description clearly shows that by "Malay" Captain Moresby means "Polynesian," the characters mentioned being in almost every respect directly the opposite of those of the true Malays, as indicated by the words and phrases here placed in italics. And, even as compared with the typical brown Polynesians, the frizzled hair, aquiline noses, and Jewish cast of features, are all Papuan characteristics.

Mr. Octavius C. Stone describes the Motu tribe who inhabit the coast districts about Redscar Bay and Port Moresby as somewhat shorter than the Papuans to the westward, and of a color varying from light brown to chocolate. The hair varies from nearly straight to woolly, often being frizzled out like that of the typical Papuan. The hair on the face is artificially eradicated, and they are thus made to appear beardless. The nose is aquiline and thick, and in a small percentage of the men the Jewish type of features appears. The adjacent tribes differ somewhat. The Koiari, Ilema, and Maiva are generally darker in color; while the Kirapuno are lighter. These last live near Hood Point, and are the handsomest people in New Guinea. Their hair is of a rich auburn, often golden in the children, growing in curls or ringlets. It is this tribe that keep their villages in such excellent order, with

* "Journal of the Royal Geographical Society," vol. xlv., p. 163.

well-kept gardens in which they even cultivate flowers. Mr. Lawes says: "We were all amazed at the cleanliness, order, and industry, which everywhere declared themselves in this model New Guinea village. The men are physically very fine and the women good-looking. One of the belles of the place had no less than fifty-four tortoise-shell ear-rings in her two ears, and her nose pierced too."*

Speaking of all these tribes as forming essentially one race, Mr. Stone says that they are a merry, laughter-loving people, fond of talking, and loving a joke, hot of temper, and quick to resent a supposed injury—all of which are Polynesian or Papuan as opposed to Malayan characteristics. They are clean in their habits, and particularly so in their eating. When allowed liberties they do not fail to take advantage; and, at Port Moresby in particular, they are accomplished thieves, inveterate liars, confirmed beggars, and ungenerous to a degree, so that, even if starving, they would give you nothing without an equivalent. This condemnation, however, does not apply to the interior tribes who have not yet been demoralized by European visitors. Both sexes are vain of their outward appearance, oiling their bodies, and adorning themselves with shells, feather and bone ornaments; and on all festive occasions each tries to outvie the other in his or her toilet. Their dress is like that of the Papuans, a T-bandage for the men, a fringe of leaves for the women, but the latter are more carefully made than among the more savage tribes. They practice true tattooing, the women especially being often highly ornamented with complex patterns on the body and limbs, and occasionally on the face also, but wanting the elegant curves and graceful designs which characterize Polynesian tattooing.* Their weapons are spears, shields, stone clubs, and hatchets, one tribe only—the Ilema—making bows and arrows. In like manner the Motu tribe only make pottery, which the other tribes obtain from them by barter. They use drilling-machines with a spindle-wheel and cord, like the Polynesians. The houses, whether on the shore or inland, are raised on piles, but are small as compared with those of the Papuans, each accommodating one or two families only.

Intellectually these people are considerably advanced. They can reckon up to a million. They use the outstretched arms as a unit to measure by. They divide the year into thirteen months, duly named, and reckoned from the new moons. The four winds and many of the stars have names, as well as every tree, shrub, flower, and even each well-marked grass and fern. They prefer fair to dark people, and are thus disposed to like and admire the white races. The children are very merry, and have many toys and games. The Rev. W. Turner tells us that they make small windmills of cocoanut-leaves, and are well versed in the mysteries of cat's-cradle; while spinning a button

* Journal kept by Mr. Lawes, "Times," November 27, 1876.

† See figures illustrating the Rev. W. Turner's article on "The Ethnology of the Motu," in the "Journal of the Anthropological Institute," 1878, p. 480.

or round piece of shell on a cord, and keeping a bladder in the air by patting it with the hands, are favorite games. They also amuse themselves with miniature spears and bow and arrows, catching fish, which they cook for themselves on the shore. They are left to do what they like, and know nothing of the tasks of school, the troubles of keeping their clothes clean, or the miseries of being washed—troubles that vex the lives of almost all civilized children. According to Mr. Turner, the villages of the Motu are by no means clean, all manner of filth being left about unheeded; and, as this agrees with most other descriptions, we must conclude that the model village already referred to is quite exceptional in its cleanliness and order.

Mr. Turner thinks the Motu are colonists from some other land, while he considers the Koiari of the interior to be "evidently the aborigines of this part of New Guinea." Mr. Stone, on the other hand, classes them together as slightly differing tribes of the same race, the one being a little more advanced than the other; and he considers the whole eastern peninsula of New Guinea to be peopled by a race of Polynesian blood, who, in some far-distant time, found their way to the coast, intermingled with the native Papuan tribes, and gradully drove them westward. There have thus resulted a number of separate tribes, showing various degrees of intermixture, the Polynesian blood predominating on the coast, the Papuan in the interior; one small tribe alone, the Kirapuno, being more distinctly Polynesian. How complete is the intermixture, and how difficult it is to determine the limits of the two races, are shown by the opinion of Mr. S. McFarlane, who says that though he at first thought the people of Katow River and those of Redscar Bay to be quite distinct, the former Papuan and the latter Malayan (or more properly Polynesian), yet, after five years' acquaintance with them, he believes them to of the same race; while he considers the tribes of the interior to be distinct, and to be true Papuans. The coast people he thinks to be the result of an intermixture of Malays, Polynesians, Arabs, Chinese, and Papuans.

Dr. Comrie (of the surveying ship Basilisk) believes that all the tribes on the northeast coast, from East Cape to Astrolabe Bay, are Papuans; but his description of them shows that they have a slight infusion of Polynesian blood, and many Polynesian customs. One thing is very clear, that neither in physical nor mental characteristics do these people show any resemblance whatever to Malays, who are a very different race from the Polynesian. The graceful figures, the woolly or curly hair, the arched noses, the use of tattooing, the ignorance of pottery-making, the gay and laughter-loving disposition, the talkativeness of the women, the lying, thievishness, and beggary, widely separate them from the Malay; while all these peculiarities support the view of their being a race formed by a mixture of Polynesian men with Papuan or Melanesian women, the former having perhaps arrived in successive waves of immigration, thus causing the coast tribes, and those nearest the east-

ern end of the island, to be more distinctly Polynesian in character than those inland and toward the west.

Returning now to the dark Papuan tribes of the remainder of New Guinea, we find that here also there is some difference of opinion. Owing to the coast tribes being usually at war with those of the interior, these latter have been described by them as a different race, and have been called by the Dutch and other writers Alfuros * or Harafuras, a term applied to any wild people living in the interior of a country, as opposed to the coast tribes. This has led many writers to class the natives of New Guinea into Papuans and Harafuras, terms which are still sometimes used, but which are quite erroneous as implying any physical difference or any distinction of race. Dr. Meyer, who has seen much of the people of the northwest coast, considers that there is no difference of the slightest importance between the coast and inland tribes, but such as occur in every race. Dr. Miklucho Maclay concludes that the Papuan stock consists of numerous varieties, with no sharp lines of demarkation. Dr. Beccari, however, differs somewhat from the preceding writers ; and as he explored a great range of country, and made repeated visits to the western half of New Guinea, his opinion is entitled to great weight. He thinks there are three distinct types of Papuans. One is dwarfish, with short woolly hair, skin almost or quite black, nose much depressed, forehead extremely narrow and slanting, and with a brachycephalous cranium ; these he terms Oriental negroes or Primitive Papuans. They do not now exist as a race, but are scattered among the interior tribes, and their description accords very closely with that of the Negritos of the Philippines and the Semangs of the Malay Peninsula. The next are the Typical Papuans, who are most widely spread, and present most of the characteristic features we have already described. The last are the Mafu or Mafor Papuans who inhabit Dorey and the shores and islands of Geelvink Bay, and are probably scattered all round the western coasts. They form the highest type, with fine Jewish or European features, a better intellect, and a somewhat more advanced civilization. These people divide the year into lunar months, each with a proper name, and have names for the four cardinal points, for many stars, and for entire constellations. Dr. Beccari believes them to be the result of an intermixture (at a remote epoch) of Hindoo or Caucasian blood with the indigenes of the island, and he even traces a connection between their rude mythology and that of the Hindoos.

A curious point of physiological detail may here be noticed as lending some support to this theory. Almost all observers have remarked that the fully developed Papuan mop of hair is not a general feature in any of the tribes, but occurs sporadically over a wide area, is highly

* The term is derived from the Portuguese "fora," out or outside ; Alfores being applied to tribes out of or beyond the settlement on the coast (Windsor Earl's "Papuans," p. 62).

valued by its possessors, and from its extreme conspicuousness is always noticed by travelers. No other *race* of people in the world possesses this character at all; but, strange to say, it appears very fully developed among the Cafusos of Brazil. These are a mixed race, the produce of negro and Indian parents, and their enormous wigs of frizzly hair have been described by Spix and Martius, and are known to most South American travelers. Still more interesting is the appearance of a similar peculiarity among the Arab tribes of Taku in eastern Africa, where mixtures of negro and Arab blood are very common.* It is well known that hybrid and mongrel characters are liable to great variation, and are very uncertain in their appearance or degree of development. If, therefore, the higher type of Papuans are the result of a remote intermixture of Hindoos or Arabs with the indigenous Papuans, we can account both for the appearance of the great mop of frizzly hair and for its extremely unequal development; and it is not improbable that the Jewish and greatly elongated nose may have a similar origin.

If we now take account of all the evidence yet obtained, we seem justified in concluding that the great mass of the inhabitants of New Guinea form one well-marked race—the Papuan—varying within comparatively narrow limits, and everywhere presenting distinctive features which separate it from all other races of mankind. The only important deviation from the type occurs in the southeastern peninsula, where a considerable Polynesian immigration has undoubtedly taken place, and greatly modified the character of the population. At other points immigrants from some of the surrounding islands may have formed small settlements, but it is a mistake to suppose that there are any Malay colonies on the southwest coast, though some of the natives may have adopted the Malay dress and some of the outward forms of Mohammedanism.

If we look over the globe for the nearest allies of the Papuans, we find them undoubtedly in equatorial and southern Africa, where alone there is an extensive and varied race of dark-colored, frizzly-haired people. The connecting links are found in the dwarfish, woolly-haired tribes of the Philippines, the Malay Peninsula, and the Andaman Islands; and, taking these altogether, we may well suppose them to represent one of the earliest, if not actually the most primitive type of man. It is customary to consider the Australians to be a lower race, and they undoubtedly are so intellectually, but this by no means proves that they are more primitive. The Australian's hair is fine and glossy like our own; and no one can look at a good series of photographs of natives without being struck with the wonderful resemblance many of them bear to countenances familiar to us at home—coarse and brutalized indeed, but still unmistakably similar.

We must also take note of the fact that the two great woolly-haired

* Waitz's "Anthropology," English translation, vol. i., p. 175.

races are almost entirely confined within the tropics, and both attain their highest development near the equator. It is here that we should expect the primitive man to have appeared, and here we still find what may well be his direct descendants thriving best. We may, perhaps, even look on the diverse types of the other great races as in part due to changes of constitution adapting them to cooler climates and changed conditions ; first, the Australians and the hill tribes of central India, who once perhaps spread far over the northern hemisphere, but have been displaced by the Mongoloid type, which flourishes at this day from the equator to the pole. These, again, have been ousted from some of the fairest regions of the temperate zone by the Indo-Europeans, who seem only to have attained their full development and highest vigor when exposed to the cold winds and variable climate of the temperate regions.

If this view is correct, and the Papuans really form one branch of the most primitive type of man which still exists on the globe, we shall continue to look upon them with ever-increasing interest, and shall welcome every fact relating to them as important additions to the history of our race. The further exploration of their beautiful and luxuriant island will, it is to be hoped, be vigorously pursued, not only to obtain the mineral, vegetable, and animal treasures that still lie hid in its great mountain ranges, but also to search for the remains of primeval man in caves or alluvial deposits, and thus throw light on the many interesting problems suggested by the physical peculiarities and insular position of the Papuan race.—*Contemporary Review.*

DANGERS OF DARWINISM.*

MR. DARWIN has certainly achieved the distinction of being recognized as the "bogey" of his generation. What Bonaparte was to the English tradesman and his family at the beginning of this century, the great evolutionist is at present to pious Clapham and chapel-going Holloway. Vast numbers of virtuous vestrymen frighten the old women of their parishes with the mere mention of his name. Sentiments and sayings are put into his mouth which would come equally well from that of the enemy of mankind. His conspiracy against the peace of the British matron is so diabolical that even bishops sometimes thunder at him, and good people of an old-fashioned way of thinking have a conviction that he ought, in this world or another, to be burned. It is no use for tender-hearted clergymen, in the great reviews and elsewhere, to recommend him to mercy, and to suggest that his theories after all may not be altogether so infamous as

* "The Darwinian Theory Examined." London: Bickers & Sons.

the lovers of damnation would insinuate. It is no use for him, himself, to mildly plead that he is no iconoclast, and makes no pretense whatever to have fathomed the solemn mysteries of Nature. His great offense has been committed, and he is condemned out of the mouth of his enemies to moral excommunication. Curiously enough, those most indignant at the suggestion of an ape-like ancestry are the individuals who are pretty generally admitted to be descendants of quite another species. By these the dangers of Darwinism are proclaimed with unwearied iteration, and thus the bray of the donkey confutes the folly which affirms man to be an offshoot of some archetypal baboon.

The author of this "Darwinian Theory Examined" is anonymous, but from the anxiety he shows to be "written down" *not* an ape, we have no hesitation in saying that he belongs to the Dogberry family of dissenters from the faith of modern science. Under what temptation he first thought of coming forward as the critic of Darwinism, and of speaking so loudly on behalf of the claims of his own ancestry, we are at a loss to guess; but we may at once say that he has made us fully alive to the limitations of the great modern theory of man's descent. A theory which relegates all men to the great monkey family, and makes no account of those who confidently establish and vindicate a descent from the four-footed companion of Balaam, must be defective somewhere, as our anonymous author shows. With a charming coherence, he compares Darwinism to phrenology, and again to mesmerism, and again to what he calls phrenomesmerism. "None of these," he says, "could have sprung from nothing (*sic*) that was reasonable; they all held on by the skirts of truth, and they have all had their hour of triumph"; and he continues, "Every one of a certain age may remember how phrenology flourished, how people hired servants, selected associates, and so forth, by its rules." We ourselves are of a certain age, but we really don't remember so much; and the period when people "hired servants" and "selected associates" by feeling their bumps must have been previous to our editorial infancy. There is now a danger, we presume, that people may do such things by the rules of Darwinism, but the author fails to inform us whether we are likely to "select" servants and intimate friends because they do, or because they do not, present in their faces and on their persons indications of their apely origin? As to the common results of the theory, however, he is far more explicit, and the case that he reports is so awful that we hope all our readers will take warning. "A man," he says, "was lately reported in America as giving a lecture, at the close of which he had advertised his intention to destroy himself. The audience was considerable. . . . Having concluded a most interesting discourse, he, in compliance with his advertised intention, before any one could interfere, drew a pistol out of his pocket and blew his brains out. *At his lodging was found a will, leaving all his property to purchase the works of Darwin, Tyndall, and Huxley for the public library of the district.*"

After that, can any rational being doubt that Mr. Darwin has much to answer for? "Such," the author triumphantly cries, "being some of the Darwinian theory's proved results (!), its suppression on the ground of being contrary to Nature and her true interpretation is clearly an object much to be desired"!!

When our author descends from generalities and comes to tackle Mr. Darwin on his own ground, his intellectual feats are simply marvelous. In answer to the philosopher's question whether differences of bodily structure and mental faculties are transmitted to offspring, he replies that the "answer is in the negative, because we every day see tall fathers with short sons, and the reverse—wise men and thrifty, with fools and spendthrifts for children!" Nevertheless, he naively confesses a little further on that "hereditary peculiarities certainly exist." His reflections are both profound and elevating: "Facially there are men and women who bear strong resemblance to owls, baboons, and other of the lower order of animals. In fact, an illustrated book has been published concerning these peculiarities; but these are not to the point, and prove nothing." Then why adduce them? a poor heathen might demand; but really we can not follow our author through the phases of his deep and dangerous argument. He gives it to Mr. Darwin tremendously, and is very high and haughty with him whenever he catches him prevaricating. Sometimes, indeed, he is barely civil: "This argument is of the *lucus a non lucendo* order, and the premises are as false as the conclusion." When the poor philosopher mildly dissents, he is ready to disconcert him altogether with an aside to the reader: "And here I may remark that the French Academy deliberately and wisely refused him (Mr. Darwin) admission into their body (three times, I have heard), for the reason that his views of Nature were not legitimately founded on facts or science." He adds loftily, in the finest manner of Mr. Podsnap: "Of this I have not personal knowledge; I have only been told so."

Here and there he is almost too hard on Mr. Darwin, as when he says: "His approach to the deep mysteries of Nature is in the *veni, vidi, vici* style, little affected by the fact that he has no power of himself to make the lowest living form of being." Really, Mr. Darwin makes no pretense to any powers of creation, unless it be in a modest literary way. Again, our critic says that, on a review of the whole "Descent of Man," this strikes him: "That any one, who can discover legitimate proof of the origin of man in its assumption, may truly be said to see with the eyes of Darwin, and not with those of God." Really, all an ordinary man can do is to see with his own eyes, if he possesses any, and not even a critic of superhuman stupidity could do much more. We regret to see these blemishes on so characteristic a book, for we are sure that it is one that will be welcomed by many a frightened matron, and by not a few seraphic spinsters. Such a work was wanted, not only to exhibit the dangers of Darwinism in its pos-

sible effects on the inmates of Hanwell, but to concentrate in one concise and complete *vade mecum* all the irrelevant twaddle of the ancient house of Dogberry. If Mr. Darwin survives this attack, he will at least know that the force of utter flabbiness can go no further. To the present generation he is a very Goliath of the Philistines; but, though the cranium of a catarrhine-ape may some day confute him, he is not to be annihilated in this off-hand fashion by the jawbone of an ass.—*Examiner.*

DISEASE OF THE BODY AS A MENTAL STIMULANT.

DURING special states of disease the mind sometimes develops faculties such as it does not possess when the body is in full health. Some of the abnormal qualities thus exhibited by the mind seem strikingly suggestive of the possible acquisition by the human race of similar powers under ordinary conditions. For this reason, though we fear there is no likelihood at present of any practical application of the knowledge we may obtain on this subject, it seems to us that there is considerable interest in examining the evidence afforded by the strange powers which the mind occasionally shows during diseases of the body, and especially during such diseases as are said, in unscientific but expressive language, to lower the tone of the nervous system.

We may begin by citing a case which seems exceedingly significant. Miss H. Martineau relates that a congenital idiot, who had lost his mother when he was less than two years old, when dying, "suddenly turned his head, looked bright and sensible, and exclaimed, in a tone never heard from him before, 'O my mother! how beautiful!' and sank down again—dead." Dr. Carpenter cites this as a case of abnormal memory, illustrating his thesis that the basis of recollection "may be laid at a very early period of life." But the story seems to contain a deeper meaning. The poor idiot not only recalled a long-past time, a face that he had not seen for years except in dreams, but he gained for a moment a degree of intelligence which he had not possessed when in health. The quality of his brain was such, it appears, that with the ordinary activity of the circulation, the ordinary vitality of the organ, mental action was uncertain and feeble; but when the circulation had all but ceased, when the nervous powers were all but prostrate, the feeble brain, though it may have become no stronger actually, became relatively stronger, in such sort that for the time being, a mere moment before dissolution, the idiot became an intelligent being.

A somewhat similar case is on record in which an insane person, during that stage of typhus fever in which sane persons are apt to become delirious, became perfectly sane and reasonable, his insanity re-

turning with returning health. Persons of strongest mind in health are often delirious for a short time before death. Since, then, the idiot in the same stage of approaching dissolution may become intelligent, while the insane may become sane under the conditions which make the sane become delirious, we recognize a relationship between the mental and bodily states which might be of considerable use in the treatment of mental diseases. It may well be that conditions of the nervous system which are to be avoided by persons of normal mental qualities may be advantageously superinduced in the case of those of abnormally weak or abnormally violent mind. It is noteworthy that different conditions would seem to be necessary for the idiotic and for the insane, if the cases cited sufficed to afford basis for generalization. For the idiot of Miss Martineau's story became intelligent during the intense depression of the bodily powers immediately preceding dissolution, whereas the insane person became sane during that height of fever when delirium commonly makes its appearance.

Sir H. Holland mentions a case which shows how great bodily depression may affect a person of ordinarily clear and powerful mind. "I descended on one and the same day," he says, "two very deep mines in the Hartz Mountains, remaining some hours underground in each. While in the second mine, and exhausted both from fatigue and inanition, I felt the utter impossibility of talking longer with the German inspector who accompanied me. Every German word and phrase deserted my recollection; and it was not until I had taken food and wine, and been some time at rest, that I regained them again."

A change in the mental condition is sometimes a sign of approaching serious illness, and is felt to be so by the person experiencing it. An American writer, Mr. Butterworth, quotes the following description given by a near relative of his who was suffering from extreme nervous debility: "I am in constant fear of insanity," she said, "and I wish I could be moved to some retreat for the insane. I understand my condition perfectly; my reason does not seem to be impaired; but I can think of *two things at the same time*. This is an indication of mental unsoundness, and is a terror to me. I do not seem to have slept at all for the last six months. If I sleep, it must be in a succession of vivid dreams that destroy all impression of somnolence. Since I have been in this condition, I seem to have a very vivid impression of what happens to my children who are away from home, and I am often startled to hear that these impressions are correct. I seem to have also a certain power of anticipating what one is about to say, and to read the motives of others. I take no pleasure in this strange increase of mental power; it is all unnatural. I can not live in this state long, and I often wish I were dead."

It must, however, be remembered that persons who are in a state of extreme nervous debility not only possess at times abnormal mental qualities, but are also affected morally. As Huxley has well remarked

of some stories bearing on spiritualism, they come from persons who can hardly be trusted even according to their own account of themselves. Mr. Butterworth's relation described a mental condition which, even if quite correctly pictured as she understood it, may yet be explained without believing that any very marvelous increase had taken place in her mental powers. Among the vivid impressions which she constantly had of what might be happening to her children away from home, it would have been strange if some had not been correct. The power of anticipating what others were about to say is one which many imagine they have, mistaking the occasional coincidence between their guesses and what has been next said for indications of a power which in reality they do not possess. And so also with regard to the motives of others. Many are apt, especially when out of health, to guess at others' motives, sometimes rightly, but oftener very wrongly, yet always rightly in their own belief, no matter what evidence may presently appear to the contrary.

The case cited by Mr. Butterworth affords evidence rather of the unhealthy condition of the patient's mind than of abnormal powers, except as regards the power of thinking of two things at the same time, which we may fairly assume was not ordinarily possessed by his relatives. It is rather difficult to define such a power, however. Several persons have apparently possessed the power, showing it by doing two things at the same time which both appear to require thought, and even close attention. Julius Cæsar, for example, could write on one subject and dictate on another simultaneously. But, in reality, even in cases such as these, the mind does not think of two things at once. It simply takes them in turn, doing enough with each, in a short time, a mere instant, perhaps, to give work to the pen or to the voice, as the case may be, for a longer time. When Cæsar was writing a sentence, he was not necessarily thinking of what he was writing. He had done the thinking part of the work before; and was free, while continuing the mere mechanical process of writing, to think of matter for dictation to his secretary. So also while he was speaking, he was free to think of matter for writing. If, indeed, the thought for each sentence of either kind had occupied an appreciable time, there would have been interruptions of his writing, if not of his dictation (dictation is not commonly a continuous process under any circumstances, even when shorthand writers take down the words). But a practiced writer or speaker can in a moment form a sentence which shall occupy a minute in writing and several seconds in speaking.

The present writer, who certainly does not claim the power of thinking of two things at once (nay, believes that no one ever had or could have such a power), finds it perfectly easy, when lecturing, to arrange the plan for the next ten minutes' exposition of a scientific subject, and to adopt the words themselves for the next twenty seconds or so, while continuing to speak without the least interruption. He has also worked

out a calculation on the blackboard, while continuing to speak of matters outside the subject of the calculation. It is more a matter of habit than an indication of any mental power, natural or acquired, to speak or write sentences, even of considerable length, after the mind has passed on to other matters. In a similar way some persons can write different words with the right and left hands, and this, too, while speaking of other matters. (We have seen this done by Professor Morse, the American naturalist, whose two hands added words to the diagrams he had drawn while his voice dealt with other parts of the drawing; to add to the wonder, too, he wrote the words indifferently from right to left or from left to right.) In reality the person who thus does two things at once is no more thinking of two things at once than a clock is, when the striking and the working machinery are both in action at the same time.*

As an illustration of special mental power shown in health, by a person whose mental condition in illness we shall consider afterward, Sir Walter Scott may be mentioned. The account given by his amanuensis has seemed surprising to many, unfamiliar with the nature of literary composition (at least after long practice), but is in reality such as any one who writes much can quite readily understand, or might even have known must necessarily be correct. "His thoughts," says the secretary to whom Scott dictated his "Life of Napoleon Bonaparte,"

* Since the above was written we have noticed a passage in Dr. Carpenter's "Mental Physiology," p. 719, bearing on the matter we have been dealing with: "The following statement recently made to the writer by a gentleman of high intelligence, the editor of a most important provincial newspaper, would be almost incredible, if cases somewhat similar were not already familiar to us: 'I was formerly,' he said, 'a reporter in the House of Commons; and it several times happened to me that, having fallen asleep from sheer fatigue toward the end of a debate, I had found, on awaking after a short interval of entire unconsciousness, that I had continued to note down correctly the speaker's words. I believe,' he added, 'that this is not an uncommon experience among Parliamentary reporters.' The reading aloud with correct emphasis and intonation, or the performance of a piece of music, or (as in the case of Albert Smith) the recitation of a frequently repeated composition, while the conscious mind is *entirely engrossed* in its own thoughts and feelings, may be thus accounted for without the supposition that the mind is actively engaged in two different operations at the same moment, which would seem tantamount to saying that there are two egos in the same organism." An instance in the writer's experience seems even more remarkable than the reporter's work during sleep, for he had but to continue a mechanical process, whereas in the writer's case there must have been thought. Late one evening at Cambridge the writer began a game of chess with a fellow student (now a clergyman, and well known in chess circles). The writer was tired after a long day's rowing, but continued the game to the best of his ability until at a certain stage he fell asleep, or rather fell into a waking dream. At any rate, all remembrance of what passed after that part of the game had entirely escaped him when he awoke or returned to consciousness about three in the morning. The chess-board was there, but the men were not as when the last conscious move was made. The opponent's king was checkmated. The writer supposed his opponent had set the men in this position either as a joke or in trying over some end game. But he was assured that the game had continued to the end, and that he (the writer) had won, apparently playing as if fully conscious! Of course, he can not certify this of his own knowledge.

"flowed easily and felicitously, without any difficulty to lay hold of them or to find appropriate language" (which, by the way, is more than all would say who had read Scott's "Life of Bonaparte," and certainly more than can be said of his secretary, unless it really was a familiar experience with him to be unable to lay hold of his thoughts). "This was evident by the absence of all solicitude (*miseria cogitandi*) from his countenance. He sat in his chair, from which he rose now and then, took a volume from the bookcase, consulted it, and restored it to the shelf—all without intermission in the current of ideas, which continued to be delivered with no less readiness than if his mind had been wholly occupied with the words he was uttering. It soon became apparent to me, however, that he was carrying on two distinct trains of thought, one of which was already arranged and in the act of being spoken, while at the same time he was in advance, considering what was afterward to be said. This I discovered" (he should rather have said, "this I was led to infer") "by his sometimes introducing a word which was wholly out of place—*entertained* instead of *denied*, for example—but which I presently found to belong to the next sentence, perhaps four or five lines further on, which he had been preparing at the very moment when he gave me the words of the one that preceded it." In the same way the present writer has unconsciously substituted one word for another in lecturing, the word used always belonging to a later sentence than the word intended to be used. We have noticed also this peculiarity, that, when a substitution of this kind has been once made, an effort is required to avoid repeating the mistake, even if it be not repeated quite unconsciously to the end of the discourse. In this way, for example, the writer once throughout an entire lecture used the word "heavens" for the word "screen" (the screen on which lantern pictures were shown). A similar peculiarity may be noticed with written errors. Thus in a treatise on a scientific subject, in which the utmost care had been given to minute points of detail, the present writer once wrote "seconds" for "minutes" throughout several pages—in fact, from the place where first the error was made, to the end of the chapter. (See the *first* edition of Proctor's "Transits of Venus," pp. 131–136, noting as an additional peculiarity that the whole object of the chapter, in which this mistake was made, was to show how many minutes of difference existed between the occurrence of certain events.)

An even more curious instance of a mistake arising from doing one thing while thinking of another occurred to the writer fourteen years ago. He was correcting the proof-sheets of an astronomical treatise in which occurred these words: "Calling the mean distance of the earth 1, Saturn's mean distance is 9·539; again, calling the earth's period 1, Saturn's mean period is 29·457: now, what relation exists between these numbers 9·539 and 29·457 and their powers? The first is less than the second, but the square of the first is plainly greater than the second; we must therefore try higher powers," etc. The passage was

quite correct as it stood, and, if the two processes by which the writer was correcting verbal errors and following the sense of the passage had been really continuous processes of thought, unquestionably the passage would have been left alone. If the passage had been erroneous and had been simply left in that condition, the case would have been one only too familiar to those who have had occasion to correct proofs. But what the writer actually did was deliberately to make nonsense of the passage while improving the balance of the second sentence. He made it run, "The first is less than the second, but the square of the first is plainly greater than the square of the second," the absurdity of which statement a child would detect. If the first proof in its correct form, with the incorrect correction carefully written down in the margin, had not existed, when, several months later, the error was pointed out in the "Quarterly Journal of Science," the writer would have felt sure that he had written the words wrongly at the outset. For blunders such as this are common enough. But, that he should deliberately have taken a correctly worded sentence and altered it into utter absurdity, he could not, but for the evidence, have believed to be possible. The case plainly shows that not only may two things be done at once, when the mind, nevertheless, is thinking only of one, but that something may be done which suggests deliberate reflection, when in reality the mind is elsewhere or not occupied at all. For in this case both the processes on which the writer was engaged were manifestly carried on without thought, one being purely mechanical, and the other, though requiring thought if properly attended to, being so imperfectly effected as to show that no thought was given to it.

To return to Sir Walter Scott. It is known but too well that during the later years of his life there came with bodily prostration a great but not constant failure of his mental powers. Some of the phenomena presented during this part of his career are strikingly illustrative of abnormal mental action occurring even at times when the mental power is on the whole much weakened. "The Bride of Lammermoor," though not one of the best of Scott's novels, is certainly far above such works as "Count Robert of Paris," "The Betrothed," and "Castle Dangerous." Its popularity may perhaps be attributed chiefly to the deep interest of the "ower true tale" on which it is founded; but some of the characters are painted with exceeding skill. Lucy herself is almost a nonentity, and Edgar is little more than a gloomy, unpleasant man, made interesting only by the troubles which fall on him. But Ailsie Gourlay and Caleb Balderstone stand out from the canvas as if alive; they are as lifelike and natural, yet as thoroughly individualized, as Edie Ochiltree and Meg Merrilies. The novel neither suggested when it first appeared, nor has been regarded even after the facts became known, as suggesting that Scott, when he wrote it, was in ill health. Yet it was produced under pressure of severe illness, and when Scott was at least in this sense unconscious, that nothing of what he said and did in connection with

the work was remembered when he recovered. "The book," says James Ballantyne, "was not only written, but published, before Mr. Scott was able to rise from his bed; and he assured me that, when it was first put into his hands in a complete shape, *he did not recollect one single incident, character, or conversation it contained!* He did not desire me to understand, nor did I understand, that his illness had erased from his memory the original incidents of the story, with which he had been acquainted from his boyhood. These remained rooted where they had ever been; or, to speak more explicitly, he remembered the general facts of the existence of the father and mother, of the son and daughter, of the rival lovers, of the compulsory marriage, and the attack made by the bride upon the hapless bridegroom, with the general catastrophe of the whole. *All these things he recollected*, just as he did before he took to his bed; *but he literally recollected nothing else*—not a single character woven by the romancer, not one of the many scenes and points of humor, not *anything with which he was himself connected*, as the writer of the work."

Later, when Scott was breaking down under severe and long-continued labor, and first felt the approach of the illness which ultimately ended in death, he experienced strange mental phenomena. In his diary for February 17, 1829, he notes that on the preceding day, at dinner, though in company witht wo or three old friends, he was haunted by "a sense of preëxistence," a confused idea that nothing that passed was said for the first time; that the same topics had been discussed, and that the same persons had expressed the same opinions before. "There was a vile sense of a want of reality in all that I did or said."

Dr. Reynolds related to Dr. Carpenter a case in which a Dissenting minister, who was in apparently sound health, was rendered apprehensive of brain-disease—though, as it seemed, without occasion—by a lapse of memory similar to that experienced by Sir Walter Scott. He "went through an entire pulpit service on a certain Sunday morning with the most perfect consistency—his choice of hymns and lessons and his *extempore* prayer being all related to the subject of his sermon. On the following Sunday morning he went through the introductory part of the service in precisely the same manner—giving out the same hymns, reading the same lessons, and directing the *extempore* prayer in the same channel. He then gave out the same text and preached the very same sermon as he had done on the previous Sunday. When he came down from the pulpit it was found that he had not the smallest remembrance of having gone through precisely the same service on the previous Sunday; and, when he was assured of it, he felt considerable uneasiness lest his lapse of memory should indicate some impending attack of illness. None such, however, supervened; and no *rationale* can be given of this curious occurrence, the subject of it not being liable to fits of "absence of mind," and not having had his thoughts engrossed at the time by any other special preoccupation." Itis possible that the

explanation here is the simple one of mere coincidence. Whether this explanation is available or not would depend entirely on the question whether the preacher's memory was ordinarily trustworthy or not, whether in fact he would remember the arrangements, prayers, sermon, etc., he had given on any occasion. These matters becoming, after long habit, almost automatic, it might very well happen that the person going through such duties would remember them no longer and no better than one who had been present when they were performed, and who had not paid special attention to them. That if he had thus unconsciously carried out his duties on one Sunday he should (being to this degree forgetful) conduct them in precisely the same way on the next Sunday, would rather tend to show that his mental faculties were in excellent working order than the reverse. Wendell Holmes tells a story which effectively illustrates our meaning; and he tells it so pleasantly (as usual) that we shall quote it unaltered: "Sometimes, but rarely," he says, "one may be caught making the same speech twice over, and yet be held blameless. Thus a certain lecturer" (Holmes himself, doubtless), "after performing in an inland city, where dwells a *littératrice* of note, was invited to meet her and others over the social teacup. She pleasantly referred to his many wanderings in his new occupation. 'Yes,' he replied, 'I am like the huma, the bird that never lights, being always in the cars as he is always on the wing.' Years elapsed. The lecturer visited the same place once more for the same purpose. Another social cup after the lecture, and a second meeting with the distinguished lady. 'You are constantly going from place to place,' she said. 'Yes,' he answered, 'I am like the huma,' and finished the sentence as before. What horrors, when it flashed over him that he had made this fine speech, word for word, twice over! Yet it was not true, as the lady might perhaps have fairly inferred, that he had embellished his conversation with the huma daily during that whole interval of years. On the contrary, he had never once thought of the odious fowl until the recurrence of precisely the same circumstances brought up precisely the same idea." He was not in the slightest degree afraid of brain-disease. On the contrary, he considered the circumstance indicative of good order in the mental mechanism. "He ought to have been proud," says Holmes, speaking for him, and meaning no doubt that he was proud, "of the accuracy of his mental adjustments. *Given certain factors, and a sound brain should always evolve the same fixed product with the certainty of Babbage's calculating machine.*"

Somewhat akin to the unconscious recurrence of mental processes after considerable intervals of time is the tendency to imitate the actions of others as though sharing in their thoughts, and according to many *because* mind acts upon mind. This tendency, though not always associated with disease, is usually a sign of bodily illness. Dr. Carpenter mentions the following singular case, but rather as illustrating generally the influence of suggestions derived from external sources in

determining the current of thought, than as showing how prone the thoughts are to run in undesirable currents when the body is out of health : "During an epidemic of fever, in which an active delirium had been a common symptom, it was observed that many of the patients of one particular physician were possessed by a strong tendency to throw themselves out of the window, while no such tendency presented itself in unusual frequency in the practice of others. The author's informant, Dr. C., himself a distinguished professor in the university, explained the tendency of what had occurred within his own knowledge ; he having been himself attacked by the fever, and having been under the care of this physician, his friend and colleague, Dr. A. Another of Dr. A.'s patients, whom we shall call Mr. B., seems to have been the first to make the attempt in question ; and, impressed with the necessity of taking due precautions, Dr. A. then visited Dr. C., *in whose hearing* he gave directions to have the windows properly secured, as Mr. B. had attempted to throw himself out. Now, Dr. C. distinctly remembers that, although he had not previously experienced any such desire, it came upon him with great urgency as soon as ever the idea was thus suggested to him ; his mind being just in that state of incipient delirium which is marked by the temporary dominance of some one idea, and by the want of volitional power to withdraw the attention from it. And he deemed it probable that, as Dr. A. went on to Mr. D., Mr. E., etc., and gave similar directions, a like desire would be excited in the minds of all those who might happen to be in the same impressible condition." The case is not only interesting as showing how the mind in disease receives certain impressions more strongly than in health, and, in a sense, may thus be said to possess for the time an abnormal power, but it affords a useful hint to doctors and nurses, who do not always (the latter indeed scarcely ever) consider the necessity of extreme caution when speaking about their patients and in their presence. It is probable that a considerable proportion of the accidents, fatal and otherwise, which have befallen delirious patients might be traced to incautious remarks made in their hearing by foolish nurses or forgetful doctors.

In some cases doctors have had to excite a strong antagonistic feeling against tendencies of this kind. Thus Zerffi relates that an English physician was once consulted by the mistress of a ladies' school where many girls had become liable to fits of hysterics. He tried several remedies, but in vain. At last, justly regarding the epidemic as arising from the influence of imagination on the weaker girls (one hysterical girl having infected the others), he determined to exert a stronger antagonistic influence on the weak minds of his patients. He therefore remarked casually to the mistress of the school, in the hearing of the girls, that he had now tried all methods but one, which he would try, as a last resource, when next he called—"the application of a red-hot iron to the spine of the patients so as to quiet their nervously excited

systems." "Strange to say," remarks Zerffi—meaning, no doubt, "it is hardly necessary to say that"—"the red-hot iron was never applied, for the hysterical attacks ceased as if by magic."

In another case mentioned by Zerffi, a revival mania in a large school near Cologne was similarly brought to an abrupt end. The Government sent an inspector. He found that the boys had visions of Christ, the Virgin, and departed saints. He threatened to close the school if these visions continued, and thus to exclude the students from all the prospects which their studies afforded them. "The effect was as magical as the red-hot iron remedy—the revivals ceased as if by magic."

The following singular cases are related in Zimmermann's "Solitude": A nun, in a very large convent in France, began to mew like a cat. At last all the nuns began to mew together every day at a certain time, and continued mewing for several hours together. This daily cat-concert continued until the nuns were informed that a company of soldiers was placed by the police before the entrance of the convent, and that the soldiers were provided with rods with which they would whip the nuns until they promised not to mew any more. . . . In the fifteenth century, a nun in a German convent fell to biting her companions. In the course of a short time all the nuns of this convent began biting each other. The news of this infatuation among the nuns soon spread, and excited the same elsewhere; the biting mania passing from convent to convent through a great part of Germany. It afterward visited the nunneries of Holland, and even spread as far as Rome." No suggestion of bodily disease is made in either case. But any one who considers how utterly unnatural is the manner of life in monastic communities will not need the evidence derived from the spread of such preposterous habits to be assured that in convents the perfectly sane mind in a perfectly healthy body must be the exception rather than the rule.

The dancing mania, which spread through a large part of Europe in the fourteenth and fifteenth centuries, although it eventually attacked persons who were seemingly in robust health, yet had its origin in disease. Dr. Hecker, who has given the most complete account we have of this strange mania, in his "Epidemics of the Middle Ages," says that when the disease was completely developed the attack commenced with epileptic convulsions. "Those affected fell to the ground senseless, panting and laboring for breath. They foamed at the mouth, and suddenly springing up began their dance amid strange contortions. They formed circles hand in hand, and appearing to have lost all control over their senses continued dancing, regardless of the bystanders, for hours together, in wild delirium, until at length they fell to the ground in a state of exhaustion. They then complained of extreme oppression, and groaned as if in the agonies of death, until they were swathed in clothes bound tightly round their waists; upon which they again recovered,

and remained free from complaint until the next attack . . . . While dancing they neither saw nor heard, being insensible to external impressions through the senses; but they were haunted by visions, their fancies conjuring up spirits, whose names they shrieked out; and some of them afterward asserted that they felt as if they had been immersed in a stream of blood, which obliged them to leap so high. Others during the paroxysm saw the heavens open, and the Saviour enthroned with the Virgin Mary, according as the religious notions of the age were strangely and variously reflected in their imaginations." The epidemic attacked people of all stations, but especially those who led a sedentary life, such as shoemakers and tailors; yet even the most robust peasants finally yielded to it. They "abandoned their labors in the fields as if they were possessed by evil spirits, and those affected were seen assembling indiscriminately from time to time, at certain appointed places, and, unless prevented by the lookers-on, continued to dance without intermission, until their very last breath was expended. Their fury and extravagance of demeanor so completely deprived them of their senses, that many of them dashed their brains out against the walls and corners of buildings, or rushed headlong into rapid rivers, where they found a watery grave. Roaring and foaming as they were, the bystanders could only succeed in restraining them by placing benches and chairs in their way, so that, by the high leaps they were thus tempted to take, their strength might be exhausted. As soon as this was the case they fell, as it were, lifeless to the ground, and by very slow degrees recovered their strength. Many there were who even with all this exertion had not expended the violence of the tempest which raged within them, but awoke with newly revived powers and again and again mixed with the crowd of dancers; until at length the violent excitement of their disordered nerves was allayed by the great involuntary exertion of their limbs, and the mental disorder was calmed by the exhaustion of the body. The cure effected by these stormy attacks was in many cases so perfect that some patients returned to the factory or plow, as if nothing had happened. Others, on the contrary, paid the penalty of their folly by so total a loss of power that they could not regain their former health, even by the employment of the most strengthening remedies."

It may be doubted, perhaps, by some whether such instances as these illustrate so much the state to which the mind is reduced when the body is diseased, as the state to which the body is reduced when the mind is diseased, though, as we have seen, the dancing mania when fully developed followed always on bodily illness. In the cases we now have to deal with, the diseased condition of the body was unmistakable.

Mrs. Hemans on her death-bed said that it was impossible for imagination to picture or pen to describe the delightful visions which passed before her mind. They made her waking hours more delightful than those passed in sleep. It is evident that these visions had their origin in the

processes of change affecting the substance of the brain as the disease of the body progressed. But it does not follow that the substance of the brain was undergoing changes necessarily tending to its ultimate decay and dissolution. Quite possibly the changes were such as might occur under the influence of suitable medicinal or stimulant substances, and without any subsequent ill effects. Dr. Richardson, in an interesting article on ether-drinking and extra-alcoholic intoxication ("Gentleman's Magazine" for October), makes a remark which suggests that the medical men of our day look forward to the discovery of means for obtaining some such influence over the action of the brain. After describing the action of methylic and ethylic ethers in his own case, he says: "They who have felt this condition, who have lived, as it were, in another life, however transitorily, are easily led to declare with Davy that 'nothing exists but thoughts! the universe is composed of impressions, ideas, pleasures, and pains!' I believe that it is so, and that we might by scientific art, and there is such an art, learn to live altogether in a new sphere of impressions, ideas, pleasures, and pains. . . . But stay," he adds, as if he had said too much, "I am anticipating, unconsciously, something else that is in my mind. The rest is silence; I must return to the world in which we now live, and which all know."

Mr. Butterworth mentions the case of the Rev. William Tennent, of Freehold, New Jersey, as illustrative of strange mental faculties possessed during disease. Tennent was supposed to be far gone in consumption. At last, after a protracted illness, he seemingly died, and preparations were made for his funeral. Not only were his friends deceived, but he was deceived himself, for he thought he was dead, and that his spirit had entered paradise. "His soul, as he thought, was borne aloft to celestial altitudes, and was enraptured by visions of God and all the hosts of heaven. He seemed to dwell in an enchanted region of limitless light and inconceivable splendor. At last an angel came to him and told him that he must go back. Darkness, like an overawing shadow, shut out the celestial glories; and, full of sudden horror, he uttered a deep groan. This dismal utterance was heard by those around him, and prevented him from being buried alive, after all the preparations had been made for the removal of the body."

We must not fall into the mistake of supposing, however, as many seem to do, that the visions seen under such conditions, or by ecstatics, really present truths of which the usual mental faculties could not become cognizant. We have heard such cases as the death-bed visions of Mrs. Hemans, and the trance visions of Tennent, urged as evidence in favor of special forms of doctrine. We have no thought of attacking these, but assuredly they derive no support from evidence of this sort. The dying Hindoo has visions which the Christian would certainly not regard as heaven-born. The Mohammedan sees the plains of paradise, peopled by the houris of his heaven, but we do not on that account accept the Koran as the sole guide to religious truth. The fact is, that

the visions pictured by the mind during the disease of the body, or in the ecstatic condition, have their birth in the mind itself, and take their form from the teachings with which that mind has been imbued. They may, indeed, seem utterly unlike those we should expect from the known character of the visionary, just as the thoughts of a dying man may be, and often are, very far removed from the objects which had occupied all his attention during the later years of his life. But if the history of the childhood and youth of an ecstatic could be fully known, or if (which is exceedingly unlikely) we could obtain a strictly truthful account of such matters from himself, we should find nearly every circumstance of his visions explained, or at least an explanation suggested. For, after all, much which would be necessary to exactly show the origin of all he saw, would be lost, since the brain retains impressions of many things of which the conscious memory has entirely passed away.

The vivid picturing of forgotten events of life is a familiar experience of the opium-eater. Thus De Quincey says: "The minutest incidents of childhood, or forgotten scenes of later years, were often revived. I could not be said to recollect them, for, if I had been told of them when waking, I should not have been able to acknowledge them as part of my past experience. But placed as they were before me in dreams like intuitions and clothed in all their evanescent circumstances and accompanying feelings, I recognized them instantaneously." A similar return of long-forgotten scenes and incidents to the mind may be noticed, though not to the same degree, when wine has been taken in moderate quantity after a long fast.

The effects of hasheesh are specially interesting in this connection, because, unless a very powerful dose has been taken, the hachischin does not wholly lose the power of introspection, so that he is able afterward to recall what has passed through his mind when he was under the influence of the drug. Now Moreau, in his interesting "Études Psychologiques" ("Du Hachich et d'Aliénation Mentale"), says that the first result of a dose sufficient to produce the *hasheesh fantasia* is a feeling of intense happiness. "It is really *happiness* which is produced by the hasheesh; and by this simply an enjoyment entirely moral, and by no means sensual as we might be induced to suppose. This is surely a very curious circumstance; and some remarkable inferences might be drawn from it; this, for instance, among others—that every feeling of joy and gladness, even when the cause of it is exclusively moral—that those enjoyments which are least connected with material objects, the most spiritual, the most ideal, may be nothing else than sensations purely physical, developed in the interior of the system, as are those procured by hasheesh. At least so far as relates to that of which we are internally conscious, there is no distinction between these two orders of sensations, in spite of the diversity in the causes to which they are due; for the hasheesh-eater is happy, not like the gourmand or the famished man when satisfying his appetite, or the voluptuary in grati-

fying his amative desires, but like him who hears tidings which fill him with joy, like the miser counting his treasures, the gambler who is successful at play, or the ambitious man who is intoxicated with success."

Our special object, however, in noting the effects of opium and hasheesh, is rather to note how the mental processes or faculties observed during certain states of disease may be produced artificially, than to enter into the considerations discussed by Dr. Moreau. It is singular that while the Mohammedan order of Hachischin (or Assassins) bring about by the use of their favorite drug such visions as accompany the progress of certain forms of disease, the Hindoo devotees called the Yogi are able to produce artificially the state of mind and body recognized in cataleptic patients. The less advanced Yogi can only enter the state of abstraction called reverie ; but the higher orders can simulate absolute inanition, the heart apparently ceasing to beat, the lungs to act, and the nerves to convey impressions to the brain, even though the body be subjected to processes which would cause extreme torture under ordinary conditions. "When in this state," says Carpenter, "the Yogi are supposed to be completely possessed by Brahma, 'the supreme soul,' and to be incapable of sin in thought, word, or deed." It has been supposed that this was the state into which those entered who in old times were resorted to as oracles. But it has happened that in certain stages of disease the power of assuming the death-like state has been possessed for a time. Thus Colonel Townsend, who died in 1797, we read, had in his last sickness the extraordinary power of apparently dying and returning to life again at will. "I found his pulse sink gradually," says Dr. Cheyne, who attended him, "so that I could not feel it by the most exact or nice touch. Dr. Raymond could not detect the least motion of the heart, nor Dr. Skrine the least soil of the breath upon the bright mirror held to the mouth. We began to fear he was actually dead. He then began to breathe softly." Colonel Townsend repeated the experiment several times during his illness, and could always render himself insensible at will.

Lastly, we may mention a case, which, however, though illustrating in some degree the influence of bodily illness on the mind, shows still more strikingly how the mind may influence the body—that of Louise Lateau, the Belgian peasant. This girl had been prostrated by a long and exhausting illness, from which she recovered rapidly after receiving the sacrament. This circumstance made a strong impression on her mind. Her thoughts dwelt constantly on the circumstances attending the death of Christ. At length she noticed that, on every Friday, blood came from a spot in her left side. "In the course of a few months similar bleeding spots established themselves on the front and back of each hand, and on the upper surface of each foot, while a circle of small spots formed in the forehead, and the hæmorrhage from these recurred every Friday, sometimes to a considerable amount. About the same time, fits of ecstasy began to occur, commencing every Friday between eight and

nine in the morning, and ending about six in the evening; interrupting her in conversation, in prayer, or in manual occupations. This state," says Dr. Carpenter, "appears to have been intermediate between that of the biologized and that of the hypnotized subject; for, while as unconscious as the latter of all sense-impressions, she retained, like the former, a recollection of all that had passed through her mind during the ecstasy. She described herself as suddenly plunged into a vast flood of bright light, from which more or less distinct forms began to evolve themselves; and she then witnessed the several scenes of the Passion successively passing before her. She minutely described the cross and the vestments, the wounds, the crown of thorns about the head of the Saviour, and gave various details regarding the persons about the cross, the disciples, holy women, Jews, and Roman soldiers. And the progress of her vision might be traced by the succession of actions she performed at various stages of it: most of these movements expressive of her own emotions, while regularly about three in the afternoon she extended her limbs in the form of a cross. The fit terminated with a state of extreme physical prostration; the pulse being scarcely perceptible, the breathing slow and feeble, and the whole surface bedewed with a cold perspiration. After this state had continued for about ten minutes, a return to the normal condition rapidly took place."

There seems no reason for supposing that there was any deceit on the part of Louise Lateau herself, though that she was self-deceived no one can reasonably doubt. Of course many in Belgium, especially the more ignorant and superstitious (including large numbers of the clergy and of religious orders of men and women), believed that her ecstasies were miraculous, and no doubt she believed so herself. But none of the circumstances observed in her case, or related by her, were such as the physiologist would find any difficulty in accepting or explaining. Her visions were such as might have been expected in a person of her peculiar nervous organization, weakened as her body had been by long illness, and her mind affected by what she regarded as her miraculous recovery. As to the transudation of blood from the skin, Dr. Tuke, in his "Illustrations of the Influence of the Mind upon the Body in Health and Disease" (p. 267), shows the phenomenon to be naturally explicable. It is a well-authenticated fact that under strong emotional excitement blood escapes through the perspiratory ducts, apparently through the rupture of the walls of the capillary passages of the skin.

We see, then, in Louise Lateau's case, how the mind affected by disease may acquire faculties not possessed during health, and how in turn the mind thus affected may influence the body so strangely as to suggest to ignorant or foolish persons the operation of supernatural agencies. Of the influence of the mind on the body, we may speak more fully on another occasion.

The general conclusion to which we seem led by the observed pecu-

liarities in the mental faculties during disease is that the mind depends greatly on the state of the body for the coördination of its various powers. In health these are related in what may be called the normal manner. Faculties capable of great development under other conditions exist in moderate degree only, while probably, either consciously or unconsciously, certain faculties are held in control by others. But during illness faculties, not ordinarily used, suddenly or very rapidly acquire undue predominance, and controlling faculties usually effective are greatly weakened. Then for a while the mental capacity seems entirely changed. Powers supposed not to exist at all (for of mental faculties, as of certain other qualities, *de non existentibus et de non apparentibus eadem est ratio*) seem suddenly created, as if by a miracle. Faculties ordinarily so strong as to be considered characteristic seem suddenly destroyed, since they no longer produce any perceptible effect. Or, as Brown-Séquard says, summing up the results of a number of illustrative cases described in a course of lectures delivered in Boston, "It would seem that the mind is largely dependent on physical conditions for the exercise of its faculties, and that its strength and most remarkable powers, as well as its apparent weakness, are often most clearly shown and recognized by some inequality of action in periods of disturbed and greatly impaired health."—*Cornhill Magazine.*

ON SENSATION AND THE UNITY OF STRUCTURE OF SENSIFEROUS ORGANS.

By Professor T. H. HUXLEY.

THE maxim that metaphysical inquiries are barren of result, and that the serious occupation of the mind with them is a mere waste of time and labor, finds much favor in the eyes of the many persons who pride themselves on the possession of sound common sense; and we sometimes hear it enunciated by weighty authorities, as if its natural consequence, the suppression of such studies, had the force of a moral obligation.

In this case, however, as in some others, those who lay down the law seem to forget that a wise legislator will consider, not merely whether his proposed enactment is desirable, but whether obedience to it is possible. For, if the latter question is answered negatively, the former is surely hardly worth debate.

Here, in fact, lies the pith of the reply to those who would make metaphysics contraband of intellect. Whether it is desirable to place a prohibitory duty upon philosophical speculations or not, it is utterly impossible to prevent the importation of them into the mind. And it

is not a little curious to observe that those who most loudly profess to abstain from such commodities are all the while unconscious consumers, on a great scale, of one or other of their multitudinous disguises or adulterations. With mouths full of the particular kind of heavily buttered toast which they affect, they inveigh against the eating of plain bread. In truth, the attempt to nourish the human intellect upon a diet which contains no metaphysics is about as hopeful as that of certain Eastern sages to nourish their bodies without destroying life. Everybody has heard the story of the pitiless microscopist, who ruined the peace of mind of one of these mild enthusiasts by showing him the animals moving in a drop of the water with which, in the innocency of his heart, he slaked his thirst; and the unsuspecting devotee of plain common sense may look for as unexpected a shock when the magnifier of severe logic reveals the germs, if not the full-grown shapes, of lively metaphysical postulates rampant amid his most positive and matter-of-fact notions.

By way of escape from the metaphysical Will-o'-the-wisps generated in the marshes of literature and theology, the serious student is sometimes bidden to betake himself to the solid ground of physical science. But the fish of immortal memory, who threw himself out of the frying-pan into the fire, was not more ill advised than the man who seeks sanctuary from philosophical persecution within the walls of the observatory or of the laboratory. It is said that "metaphysics" owe their name to the fact that, in Aristotle's works, questions of pure philosophy are dealt with immediately after those of physics. If so, the accident is happily symbolical of the essential relations of things; for metaphysical speculation follows as closely upon physical theory as black care upon the horseman.

One need but mention such fundamental, and indeed indispensable, conceptions of the natural philosopher as those of atoms and forces; or that of attraction considered as action at a distance; or that of potential energy; or the antinomies of a vacuum and a plenum; to call to mind the metaphysical background of physics and chemistry; while, in the biological sciences, the case is still worse. What is an individual among the lower plants and animals? Are genera and species realities or abstractions? Is there such a thing as Vital Force? or does the name denote a mere relic of metaphysical fetichism? Is the doctrine of final causes legitimate or illegitimate? These are a few of the metaphysical topics which are suggested by the most elementary study of biological facts. But, more than this, it may be truly said that the roots of every system of philosophy lie deep among the facts of physiology. No one can doubt that the organs and the functions of Sensation are as much a part of the province of the physiologist as are the organs and functions of motion, or those of digestion; and yet it is impossible to gain an acquaintance with even the rudiments of the physiology of sensation without being led straight to one of the most fundamental of all

metaphysical problems. In fact, the sensory operations have been, from time immemorial, the battle-ground of philosophers.

I have more than once taken occasion to point out that we are indebted to Descartes, who happened to be a physiologist as well as a philosopher, for the first distinct enunciation of the essential elements of the true theory of sensation. In later times, it is not to the works of the philosophers, if Hartley and James Mill are excepted, but to those of the physiologists, that we must turn for an adequate account of the sensory process. Haller's luminous, though summary, account of sensation in his admirable "Primæ Lineæ," the first edition of which was printed in 1747, offers a striking contrast to the prolixity and confusion of thought which pervade Reid's "Inquiry," of seventeen years' later date.* Even Sir William Hamilton, learned historian and acute critic as he was, not only failed to apprehend the philosophical bearing of long-established physiological truths; but, when he affirmed that there is no reason to deny that the mind feels at the finger-points, and none to assert that the brain is the sole organ of thought,† he showed that he had not apprehended the significance of the revolution commenced, two hundred years before his time, by Descartes, and effectively followed up by Haller, Hartley, and Bonnet, in the middle of the last century.

In truth, the theory of sensation, except in one point, is, at the present moment, very much where Hartley, led by a hint of Sir Isaac Newton's, left it, when, a hundred and twenty years since, the "Observations on Man: his Frame, his Duty, and his Expectations," was laid before the world. The whole matter is put in a nutshell in the following passages of this notable book:

External objects impressed upon the senses occasion, first on the nerves on which they are impressed, and then on the brain, vibrations of the small and, as we may say, infinitesimal medullary particles.

These vibrations are motions backward and forward of the small particles;

* In justice to Reid, however, it should be stated that the chapters on Sensation in the "Essays on the Intellectual Powers" (1785) exhibit a great improvement. He is, in fact, in advance of his commentator, as the note to Essay II., chap. ii., p. 248 of Hamilton's edition shows.

† Haller, amplifying Descartes, writes in the "Primæ Lineæ," CCCXVI.: "Non est adeo obscurum sensum omnem oriri ab objecti sensibilis impressione in nervum quemcumque corporis humani, et eamdem per eum nervum ad cerebrum pervenientem tunc demum representari animæ, quando cerebrum adtigit. Ut etiam hoc falsum sit animam inproximo per sensoria nervorumque ramos sentire." . . . DLVII.: "Dum ergo sentimus quinque diversissima entia conjunguntur: corpus quod sentimus: organi sensorii adfectio ab eo corpore: cerebri adfectio a sensorii percussione nata: in anima nata mutatio: animæ denique conscientia et sensationis adperceptio." Nevertheless, Sir William Hamilton gravely informs his hearers: "We have no more right to deny that the mind feels at the finger-points, as consciousness assures us, than to assert that it thinks exclusively in the brain."—"Lecture on Metaphysics and Logic," ii., p. 128. "We have no reason whatever to doubt the report of consciousness, that we actually perceive at the external point of sensation, and that we perceive the material reality."—Ibid., p. 129.

of the same kind with the oscillations of pendulums and the tremblings of the particles of sounding bodies. They must be conceived to be exceedingly short and small, so as not to have the least efficacy to disturb or move the whole bodies of the nerves or brain.*

The white medullary substance of the brain is also the immediate instrument by which ideas are presented to the mind; or, in other words, whatever changes are made in this substance, corresponding changes are made in our ideas; and *vice versa*.†

Hartley, like Haller, had no conception of the nature and functions of the gray matter of the brain. But, if for "white medullary substance," in the latter paragraph, we substitute "gray cellular substance," Hartley's propositions embody the most probable conclusions which are to be drawn from the latest investigations of physiologists. In order to judge how completely this is the case, it will be well to study some simple case of sensation, and, following the example of Reid and of James Mill, we may begin with the sense of smell. Suppose that I become aware of a musky scent, to which the name of "muskiness" may be given. I call this an odor, and I class it along with the feelings of light, colors, sounds, tastes, and the like, among those phenomena which are known as sensations. To say that I am aware of this phenomenon, or that I have it, or that it exists, are simply different modes of affirming the same facts. If I am asked how I know that it exists, I can only reply that its existence and my knowledge of it are one and the same thing; in short, that my knowledge is immediate or intuitive, and, as such, is possessed of the highest conceivable degree of certainty.

The pure sensation of muskiness is almost sure to be followed by a mental state which is not a sensation, but a belief, that there is somewhere close at hand a something on which the existence of the sensation depends. It may be a musk-deer, or a musk-rat, or a musk-plant, or a grain of dry musk, or simply a scented handkerchief; but former experience leads us to believe that the sensation is due to the presence of one or other of these objects, and that it will vanish if the object is removed. In other words, there arises a belief in an external cause of the muskiness, which, in common language, is termed an odorous body.

But the manner in which this belief is usually put into words is strangely misleading. If we are dealing with a musk-plant, for example, we do not confine ourselves to a simple statement of that which we believe, and say that the musk-plant is the cause of the sensation called muskiness; but we say that the plant has a musky smell, and we speak of the odor as a quality, or property, inherent in the plant.

* "Observations on Man," vol. i., p. 11.

† Ibid., p. 8. The speculations of Bonnet are remarkably similar to those of Hartley; and they appear to have originated independently, though the "Essai de Psychologie" (1754) is of five years' later date than the "Observations on Man" (1749).

And the inevitable reaction of words upon thought has in this case become so complete, and has penetrated so deeply, that when an accurate statement of the case—namely, that muskiness, inasmuch as the term denotes nothing but a sensation, is a mental state and has no existence except as a mental phenomenon—is first brought under the notice of common-sense folks, it is usually regarded by them as what they are pleased to call a mere metaphysical paradox and a patent example of useless subtilty. Yet the slightest reflection must suffice to convince any one possessed of sound reasoning faculties that it is as absurd to suppose that muskiness is a quality inherent in one plant, as it would be to imagine that pain is a quality inherent in another, because we feel pain when a thorn pricks the finger.

Even the common-sense philosopher, *par excellence*, says of smell: "It appears to be a simple and original affection or feeling of the mind, altogether inexplicable and unaccountable. It is, indeed, impossible that it can be in any body: it is a sensation, and a sensation can only be in a sentient thing."*

That which is true of muskiness is true of every other odor. Lavender-smell, clove-smell, garlic-smell, are, like "muskiness," names of states of consciousness, and have no existence except as such. But, in ordinary language, we speak of all these odors as if they were independent entities residing in lavender, cloves, and garlic; and it is not without a certain struggle that the false metaphysic of common sense, thus ingrained in us, is expelled.

It is unnecessary for the present purpose to inquire into the origin of our belief in external bodies, or into that of the notion of causation. Assuming the existence of an external world, there is no difficulty in obtaining experimental proof that, as a general rule, olfactory sensations are caused by odorous bodies; and we may pass on to the next step of the inquiry—namely, how the odorous body produces the effect attributed to it.

The first point to be noted here is another fact revealed by experience; that the appearance of the sensation is governed, not only by the presence of the odorous substance, but by the condition of a certain part of our corporeal structure, the nose. If the nostrils are closed, the presence of the odorous substance does not give rise to the sensation; while, when they are open, the sensation is intensified by the approximation of the odorous substance to them, and by snuffing up the adjacent air in such a manner as to draw it into the nose. On the other

* "An Inquiry into the Human Mind on the Principles of Common Sense, chap. ii., sec. 2. Reid affirms that "it is genius and not the want of it that adulterates philosophy, and fills it with error and false theory"; and no doubt his own lucubrations are free from the smallest taint of the impurity to which he objects. But, for want of something more than that "common sense," which is very common and a little dull, the contemner of genius did not notice that the admission here made knocks so big a hole in the bottom of "common-sense philosophy" that nothing can save it from foundering in the dreaded abyss of Idealism.

hand, looking at an odorous substance, or rubbing it on the skin, or holding it to the ear, does not awaken the sensation. Thus, it can be readily established by experiment that the perviousness of the nasal passages is, in some way, essential to the sensory function; in fact, that the organ of that function is lodged somewhere in the nasal passages. And, since odorous bodies give rise to their effects at considerable distances, the suggestion is obvious that something must pass from them into the sense-organ. What is this something which plays the part of an intermediary between the odorous body and the sensory organ?

The oldest speculation about the matter dates back to Democritus and the Epicurean school, and it is to be found fully stated in the fourth book of Lucretius. It comes to this: that the surfaces of bodies are constantly throwing off excessively attenuated films of their own substance; and that these films, reaching the mind, excite the appropriate sensations in it.

Aristotle did not admit the existence of any such material films, but conceived that it was the form of the substance, and not its matter, which affected sense, as a seal impresses wax, without losing anything in the process. While many, if not the majority, of the schoolmen took up an intermediate position, and supposed that a something which was not exactly either material or immaterial, and which they called an "intentional species," effected the needful communication between the bodily cause of sensation and the mind.

But all these notions, whatever may be said for or against them in general, are fundamentally defective, by reason of an oversight which was inevitable, in the state of knowledge at the time in which they were promulgated. What the older philosophers did not know, and could not know, before the anatomist and physiologist had done his work, is that, between the external object and that mind in which they supposed the sensation to inhere, there lies a physical obstacle. The sense-organ is not a mere passage by which the "tenuia simulacra rerum," or the "intentional species" cast off by objects, or the "forms" of sensible things, pass straight to the mind; on the contrary, it stands as a firm and impervious barrier, through which no material particle of the world without can make its way to the world within.

Let us consider the olfactory sense-organ more nearly. Each of the nostrils leads into a passage completely separated from the other by a partition, and these two passages place the nostrils in free communication with the back of the throat, so that they freely transmit the air passing to the lungs when the mouth is shut, as in ordinary breathing. The floor of each passage is flat, but its roof is a high arch, the crown of which is seated between the orbital cavities of the skull, which serve for the lodgment and protection of the eyes; and therefore lies behind the apparent limits of that feature which in ordinary language is called the nose. From the side walls of the upper and back part of these

arched chambers certain delicate plates of bone project, and these, as well as a considerable part of the partition between the two chambers, are covered by a fine, soft, moist membrane. It is to this Schneiderian, or olfactory, membrane that odorous bodies must obtain direct access if they are to give rise to their appropriate sensations; and it is upon the relatively large surface which the olfactory membrane offers that we must seek for the seat of the organ of the olfactory sense. The only essential part of that organ consists of a multitude of minute, rod-like bodies, set perpendicularly to the surface of the membrane, and forming a part of the cellular coat, or epithelium, which covers the olfactory membrane, as the epidermis covers the skin. In the case of the olfactory sense, there can be no doubt that the Democritic hypothesis, at any rate for such odorous substances as musk, has a good foundation. Infinitesimal particles of musk fly off from the surface of the odorous body, and, becoming diffused through the air, are carried into the nasal passages, and thence into the olfactory chambers, where they come into contact with the filamentous extremities of the delicate olfactory epithelium.

But this is not all. The "mind" is not, so to speak, upon the other side of the epithelium. On the contrary, the inner ends of the olfactory cells are connected with nerve-fibers, and these nerve-fibers, passing into the cavity of the skull, at length end in a part of the brain, the olfactory sensorium. It is certain that the integrity of each, and the physical interconnection of all these three structures, the epithelium of the sensory organ, the nerve-fibers, and the sensorium, are essential conditions of ordinary sensation. That is to say, the air in the olfactory chambers may be charged with particles of musk; but, if either the epithelium, or the nerve-fibers, or the sensorium is injured, or physically disconnected from one another, sensation will not arise. Moreover, the epithelium may be said to be receptive, the nerve-fibers transmissive, and the sensorium sensifacient. For, in the act of smelling, the particles of the odorous substance produce a molecular change (which Hartley was in all probability right in terming a vibration) in the epithelium, and this change, being transmitted to the nerve-fibers, passes along them with a measurable velocity, and, finally reaching the sensorium, is immediately followed by the sensation.

Thus, modern investigation supplies a representative of the Epicurean simulacra in the volatile particles of the musk; but it also gives us the stamp of the particles on the olfactory epithelium, without any transmission of matter, as the equivalent of the Aristotelian "form"; while, finally, the modes of motion of the molecules of the olfactory cell, of the nerve, and of the cerebral sensorium, which are Hartley's vibrations, may stand very well for a double of the "intentional species" of the schoolmen. And this last remark is not intended merely to suggest a fanciful parallel; for, if the cause of the sensation is, as analogy suggests, to be sought in the mode of motion of the object of sense,

then it is quite possible that the particular mode of motion of the object is reproduced in the sensorium; exactly as the diaphragm of a telephone reproduces the mode of motion taken up at its receiving end. In other words, the secondary "intentional species" may be, as the schoolmen thought the primary one was, the last link between matter and mind.

None the less, however, does it remain true that no similarity exists, nor indeed is conceivable, between the cause of the sensation and the sensation. Attend as closely to the sensations of muskiness, or any other odor, as we will, no trace of extension, resistance, or motion is discernible in them. They have no attribute in common with those which we ascribe to matter; they are, in the strictest sense of the words, immaterial entities.

Thus, the most elementary study of sensation justifies Descartes's position, that we know more of mind than we do of body; that the immaterial world is a firmer reality than the material. For the sensation "muskiness" is known immediately. So long as it persists, it is a part of what we call our thinking selves, and its existence lies beyond the possibility of doubt. The knowledge of an objective or material cause of the sensation, on the other hand, is mediate; it is a belief as contradistinguished from an intuition; and it is a belief which, in any given instance of sensation, may, by possibility, be devoid of foundation. For odors, like other sensations, may arise from the occurrence of the appropriate molecular changes in the nerve or in the sensorium, by the operation of a cause distinct from the affection of the sense-organ by an odorous body. Such "subjective" sensations are as real existences as any others, and as distinctly suggest an external odorous object as their cause; but the belief thus generated is a delusion. And, if beliefs are properly termed "testimonies of consciousness," then undoubtedly the testimony of consciousness may be, and often is, untrustworthy.

Another very important consideration arises out of the facts as they are now known. That which, in the absence of a knowledge of the physiology of sensation, we call the cause of the smell, and term the odorous object, is only such, mediately, by reason of its emitting particles which give rise to a mode of motion in the sense-organ. The sense-organ, again, is only a mediate cause by reason of its producing a molecular change in the nerve-fiber; while this last change is also only a mediate cause of sensation, depending, as it does, upon the change which it excites in the sensorium.

The sense-organ, the nerve, and the sensorium, taken together, constitute the sensiferous apparatus. They make up the thickness of the wall between the mind, as represented by the sensation "muskiness," and the object, as represented by the particle of musk in contact with the olfactory epithelium.

It will be observed that the sensiferous wall and the external world are of the same nature; whatever it is that constitutes them both is expressible in terms of matter and motion. Whatever changes take place

in the sensiferous apparatus are continuous with, and similar to, those which take place in the external world.* But, with the sensorium, matter and motion come to an end; while phenomena of another order, or immaterial states of consciousness, make their appearance. How is the relation between the material and the immaterial phenomena to be conceived? This is the metaphysical problem of problems, and the solutions which have been suggested have been made the corner-stones of systems of philosophy. Three mutually irreconcilable readings of the riddle have been offered.

The first is, that an immaterial substance of mind exists; and that it is affected by the mode of motion of the sensorium in such a way as to give rise to the sensation.

The second is, that the sensation is a direct effect of the mode of motion of the sensorium, brought about without the intervention of any substance of mind.

The third is, that the sensation is neither directly, nor indirectly, an effect of the mode of motion of the sensorium, but that it has an independent cause. Properly speaking, therefore, it is not an effect of the motion of the sensorium, but a concomitant of it.

As none of these hypotheses is capable of even an approximation to demonstration, it is almost needless to remark that they have been severally held with tenacity and advocated with passion. I do not think it can be said of any of the three that it is inconceivable, or that it can be assumed on *a priori* grounds to be impossible.

Consider the first, for example; an immaterial substance is perfectly conceivable. In fact, it is obvious that, if we possessed no sensations

* The following diagrammatic scheme may help to elucidate the theory of sensation:

Mediate Knowledge				Immediate Knowledge
	Sensiferous Apparatus			
Objects of Sense	Receptive (Sense-Organ)	Transmissive (Nerve)	Sensificatory (Sensorium)	Sensations and other States of Consciousness
Hypothetical Substance of Matter				Hypothetical Substance of Mind
Physical World				Mental World
Not Self	Self			
Non-Ego or Object				Ego or Subject

Immediate Knowledge is confined to states of consciousness, or, in other words, to the phenomena of mind. Knowledge of the physical world, or of one's own body and of objects external to it, is a system of beliefs or judgments based on the sensations. The term "self" is applied not only to the series of mental phenomena which constitute the ego, but to the fragment of the physical world which is their constant concomitant. The corporeal self, therefore, is part of the non-ego; and is objective in relation to the ego as subject.

but those of smell and hearing, we should be unable to conceive a material substance. We might have a conception of time, but could have none of extension, or of resistance, or of motion. And without the three latter conceptions no idea of matter could be formed. Our whole knowledge would be limited to that of a shifting succession of immaterial phenomena. But, if an immaterial substance may exist, it may have any conceivable properties; and sensation may be one of them. All these propositions may be affirmed with complete dialectic safety, inasmuch as they can not possibly be disproved; but neither can a particle of demonstrative evidence be offered in favor of them.

As regards the second hypothesis, it certainly is not inconceivable, and therefore it may be true, that sensation is the direct effect of certain kinds of bodily motion. It is just as easy to suppose this as to suppose, on the former hypothesis, that bodily motion affects an immaterial substance. But neither is it susceptible of proof.

And, as to the third hypothesis, since the logic of induction is in no case competent to prove that events apparently standing in the relation of cause and effect may not both be effects of a common cause—that also is as safe from refutation, if as incapable of demonstration, as the other two.

In my own opinion, neither of these speculations can be regarded seriously as anything but a more or less convenient working hypothesis. But, if I must choose among them, I take the "law of parcimony" for my guide, and select the simplest—namely, that the sensation is the direct effect of the mode of motion of the sensorium. It may justly be said that this is not the slightest explanation of sensation; but then am I really any the wiser, if I say that a sensation is an activity (of which I know nothing) of a substance of mind (of which also I know nothing)? Or, if I say that the Deity causes the sensation to arise in my mind immediately after he has caused the particles of the sensorium to move in a certain way, is anything gained? In truth, a sensation, as we have already seen, is an intuition—a part of immediate knowledge. As such it is an ultimate fact and inexplicable; and all that we can hope to find out about it, and that indeed is worth finding out, is its relation to other natural facts. That relation appears to me to be sufficiently expressed, for all practical purposes, by saying that sensation is the invariable consequent of certain changes in the sensorium—or, in other words, that, so far as we know, the change in the sensorium is the cause of the sensation.

I permit myself to imagine that the untutored, if noble, savage of common sense who has been misled into reading thus far by the hope of getting positive solid information about sensation, giving way to not unnatural irritation, may here interpellate: "The upshot of all this long disquisition is, that we are profoundly ignorant. We knew that to begin with, and you have merely furnished another example of the emptiness and uselessness of metaphysics." But I venture to reply,

pardon me, you were ignorant, but you did not know it. On the contrary, you thought you knew a great deal, and were quite satisfied with the particularly absurd metaphysical notions which you were pleased to call the teachings of common sense. You thought that your sensations were properties of external things, and had an existence outside of yourself. You thought that you knew more about material than you do about immaterial existences. And if, as a wise man has assured us, the knowledge of what we don't know is the next best thing to the knowledge of what we do know, this brief excursion into the province of philosophy has been highly profitable.

Of all the dangerous mental habits, that which schoolboys call "cocksureness" is probably the most perilous; and the inestimable value of metaphysical discipline is, that it furnishes an effectual counterpoise to this evil proclivity. Whoso has mastered the elements of philosophy knows that the attribute of unquestionable certainty appertains only to the existence of a state of consciousness so long as it exists; all other beliefs are mere probabilities of a higher or lower order. Sound metaphysic is an amulet which renders its possessor proof alike against the poison of superstition and the counter-poison of nihilism; by showing that the affirmations of the former and the denials of the latter alike deal with matters about which, for lack of evidence, nothing can be either affirmed or denied.

I have dwelt at length upon the nature and origin of our sensations of smell, on account of the comparative freedom of the olfactory sense from the complications which are met with in most of the other senses.

Sensations of taste, however, are generated in almost as simple a fashion as those of smell. In this case, the sense-organ is the epithelium which covers the tongue and the palate; and which sometimes, becoming modified, gives rise to peculiar organs termed "gustatory bulbs," in which the epithelial cells elongate and assume a somewhat rod-like form. Nerve-fibers connect the sensory organ with the sensorium, and tastes or flavors are states of consciousness caused by the change of molecular state of the latter. In the case of the sense of touch there is often no sense-organ distinct from the general epidermis. But many fishes and amphibia exhibit local modifications of the epidermic cells which are sometimes extraordinarily like the gustatory bulbs; more commonly, both in lower and higher animals, the effect of the contact of external bodies is intensified by the development of hair-like filaments, or of true hairs, the bases of which are in immediate relation with the ends of the sensory nerves. Every one must have noticed the extreme delicacy of the sensations produced by the contact of bodies with the ends of the hairs of the head; and the "whiskers" of cats owe their functional importance to the abundant supply of nerves to the follicles in which their bases are lodged. What part, if any, the so-called "tactile corpuscles," "end-bulbs," and "Pacinian bodies" play

in the mechanism of touch is unknown. If they are sense-organs, they are exceptional in character, in so far as they do not appear to be modifications of the epidermis. Nothing is known respecting the sense-organs of those sensations of resistance which are grouped under the head of the muscular sense; nor of the sensations of warmth and cold; nor of that very singular sensation which we call tickling.

In the case of heat and cold, the organism not only becomes affected by external bodies, far more remote than those which affect the sense of smell, but the Democritic hypothesis is obviously no longer permissible. When the direct rays of the sun fall upon the skin, the sensation of heat is certainly not caused by "attenuated films" thrown off from that luminary, but to a mode of motion which is transmitted to us. In Aristotelian phrase, it is the form without the matter of the sun which stamps the sense-organ; and this, translated into modern language, means nearly the same thing as Hartley's vibrations. Thus we are prepared for what happens in the case of the auditory and the visual senses. For neither the ear nor the eye receives anything but the impulses or vibrations originated by sonorous or luminous bodies. Nevertheless, the receptive apparatus still consists of nothing but specially modified epithelial cells. In the labyrinth of the ear of the higher animals the free ends of these cells terminate in excessively delicate hair-like filaments; while, in the lower forms of auditory organ, its free surface is beset with delicate hairs like those of the surface of the body, and the transmissive nerves are connected with the bases of these hairs. Thus there is an insensible gradation in the forms of the receptive apparatus, from the organ of touch, on the one hand, to those of taste and smell; and, on the other hand, to that of hearing. Even in the case of the most refined of all the sense-organs, that of vision, the receptive apparatus departs but little from the general type. The only essential constituent of the visual sense-organ is the retina, which forms so small a part of the eyes of the higher animals; and the simplest eyes are nothing but portions of the integument, in which the cells of the epidermis have become converted into glassy, rod-like retinal corpuscles. The outer ends of these are turned toward the light; their sides are more or less extensively coated with a dark pigment, and their inner ends are connected with the transmissive nerve-fibers. The light impinging on these visual rods produces a change in them which is communicated to the nerve-fibers, and, being transmitted to the sensorium, gives rise to the sensation—if indeed all animals which possess eyes are endowed with what we understand as sensation.

In the higher animals, a complicated apparatus of lenses, arranged on the principle of a camera obscura, serves at once to concentrate and to individualize the pencils of light proceeding from external bodies. But the essential part of the organ of vision is still a layer of cells which have the form of rods with truncated or conical ends. By what seems a strange anomaly, however, the glassy ends of these

are turned not toward, but away from, the light; and the latter has to traverse the layer of nervous tissues with which their outer ends are connected, before it can affect them. Moreover, the rods and cones of the vertebrate retina are so deeply seated, and in many respects so peculiar in character, that it appears impossible, at first sight, that they can have anything to do with that epidermis of which gustatory and tactile, and at any rate the lower forms of auditory and visual, organs are obvious modifications.

Whatever be the apparent diversities among the sensiferous apparatuses, however, they share certain common characters. Each consists of a receptive, a transmissive, and a sensificatory portion. The essential part of the first is an epithelium, of the second, nerve-fibers, of the third, a part of the brain; the sensation is always the consequence of the mode of motion excited in the receptive, and sent along the transmissive, to the sensorial part of the sensiferous apparatus. And, in all the senses, there is no likeness whatever between the object of sense, which is matter in motion, and the sensation, which is an immaterial phenomenon.

On the hypothesis which appears to me to be the most convenient, sensation is a product of the sensiferous apparatus caused by certain modes of motion which are set up in it by impulses from without. The sensiferous apparatuses are, as it were, factories, all of which at the one end receive raw materials of a similar kind—namely, modes of motion—while at the other each turns out a special product, the feeling which constitutes the kind of sensation characteristic of it.

Or, to make use of a closer comparison, each sensiferous apparatus is comparable to a musical box wound up, with as many tunes as there are separate sensations. The object of a simple sensation is the agent which presses down the stop of one of these tunes, and the more feeble the agent, the more delicate must be the mobility of the stop.*

But, if this be the case, if the recipient part of the sensiferous apparatus is in all cases merely a mechanism affected by coarser or finer kinds of material motion, we might expect to find that all sense-organs are fundamentally alike, and result from the modification of the same morphological elements. And this is exactly what does result from all recent histological and embryological investigations.

It has been seen that the receptive part of the olfactory apparatus is a slightly modified epithelium, which lines an olfactory chamber deeply seated between the orbits in adult human beings. But, if we trace back the nasal chambers to their origin in the embryo, we find that, to begin with, they are mere depressions of the skin of the fore-part of the head, lined by a continuation of the general epidermis. These depressions become pits, and the pits, by the growth of the adjacent parts, gradually acquire the position which they finally occupy.

* "Chaque fibre est une espèce de touche ou de marteau destiné à rendre un certain ton."—Bonnet, "Essai de Psychologie," chap. iv.

The olfactory organ, therefore, is a specially modified part of the general integument.

The human ear would seem to present greater difficulties. For the essential part of the sense-organ, in this case, is the membranous labyrinth, a bag of complicated form, which lies buried in the depths of the floor of the skull, and is surrounded by dense and solid bone. Here, however, recourse to the study of development readily unravels the mystery. Shortly after the time when the olfactory organ appears as a depression of the skin on the side of the fore-part of the head, the auditory organ appears as a similar depression on the side of its back part. The depression, rapidly deepening, becomes a small pouch, and then, the communication with the exterior becoming shut off, the pouch is converted into a closed bag, the epithelial lining of which is a part of the general epidermis segregated from the rest. The adjacent tissues, changing first into cartilage and then into bone, inclose the auditory sac in a strong case, in which it undergoes its further metamorphoses; while the drum, the ear-bones, and the external ear are superadded by no less extraordinary modifications of the adjacent parts. Still more marvelous is the history of the development of the organ of vision. In the place of the eye, as in that of the nose and that of the ear, the young embryo presents a depression of the general integument; but, in man and the higher animals, this does not give rise to the proper sensory organ, but only to part of the accessory structures concerned in vision. In fact, this depression, deepening and becoming converted into a shut sac, produces only the cornea, the aqueous humor, and the crystalline lens of the perfect eye.

The retina is added to this by the outgrowth of the wall of a portion of the brain into a sort of bag or sac with a narrow neck, the convex bottom of which is turned outward or toward the crystalline lens. As the development of the eye proceeds, the convex bottom of the bag becomes pushed in, so that it gradually obliterates the cavity of the sac, the previously convex wall of which becomes deeply concave. The sac of the brain is now like a double nightcap ready for the head, but the place which the head would occupy is taken by the vitreous humor, while the layer of nightcap next it becomes the retina. The cells of this layer which lie farthest from the vitreous humor, or, in other words, bound the original cavity of the sac, are metamorphosed into the rods and cones. Suppose now that the sac of the brain could be brought back to its original form; then the rods and cones would form part of the lining of a side pouch of the brain. But one of the most wonderful revelations of embryology is the proof of the fact that the brain itself is, at its first beginning, merely an infolding of the epidermic layer of the general integument. Hence it follows that the rods and cones of the vertebrate eye are modified epidermic cells, as much as the crystalline cones of the insect or crustacean eye are; and that the inversion of the position of the former in relation to light arises

simply from the roundabout way in which the vertebrate retina is developed.

Thus all the higher sense-organs start from one foundation, and the receptive epithelium of the eye, or of the ear, is as much modified epidermis as is that of the nose. The structural unity of the sense-organs is the morphological parallel to their identity of physiological function, which, as we have seen, is to be impressed by certain modes of motion; and they are fine or coarse in proportion to the delicacy or the strength of the impulses by which they are to be affected.

In ultimate analysis, then, it appears that a sensation is the equivalent in terms of consciousness for a mode of motion of the matter of the sensorium. But, if inquiry is pushed a stage further, and the question is asked, What then do we know about matter and motion? there is but one reply possible. All that we know about motion is that it is a name for certain changes in the relations of our visual, tactile, and muscular sensations; and all that we know about matter is that it is the hypothetical substance of physical phenomena—the assumption of the existence of which is as pure a piece of metaphysical speculation as that of the substance of mind.

Our sensations, our pleasures, our pains, and the relations of these make up the sum total of the elements of positive, unquestionable knowledge. We call a large section of these sensations and their relations matter and motion; the rest we term mind and thinking; and experience shows that there is a certain constant order of succession between some of the former and some of the latter.

This is all that just metaphysical criticism leaves of the idols set up by the spurious metaphysics of vulgar common sense. It is consistent either with pure Materialism, or with pure Idealism, but it is neither. For the Idealist, not content with declaring the truth that our knowledge is limited to facts of consciousness, affirms the wholly unprovable proposition that nothing exists beyond these and the substance of mind. And, on the other hand, the Materialist, holding by the truth that, for anything that appears to the contrary, material phenomena are the causes of mental phenomena, asserts his unprovable dogma, that material phenomena and the substance of matter are the sole primary existences.

Strike out the propositions about which neither controversialist does or can know anything, and there is nothing left for them to quarrel about. Make a desert of the Unknowable, and the divine Astræa of philosophic peace will commence her blessed reign.—*Nineteenth Century.*

RESIDUAL PHENOMENA.

By Professor PATTISON MUIR.

IN his "Preliminary Discourse on the Study of Natural Philosophy," Sir John Herschel remarks upon the importance of examining those phenomena of nature which are not wholly explicable in terms of any well-established theory. Instances of such residual phenomena, as Sir John Herschel terms them, are given in the discourse.

Newton's theory of comets, viz., that these bodies obey the law of gravitation while revolving in oblique orbits round the sun, appeared to account for the facts which had been noticed concerning the comet of Halley; but the period calculated for Encke's comet, on this hypothesis, was found to be rather longer than the actual, observed period, and, moreover, the duration of the observed period showed a small but regular diminution. Hence, Newton's theory, taken alone, was not sufficient to account for the facts. But, inasmuch as Newton's law of gravitation rested upon a sure and well-established foundation, the fact observed concerning Encke's comet could not be regarded as disproving the law; hence these facts were to be explained by tracing them to the action of some agent either of known or of, as yet, unknown nature.

The regularly diminishing period of Encke's comet remained a residual phenomenon, not contradicting the law of gravitation, but awaiting full explanation.

A residual phenomenon is, then, a phenomenon which is not fully explained by any established theory; but at the same time it is not a phenomenon which is absolutely contradictory to any such theory, for, if this were the case, the theory in question must perforce be abandoned.

Advances are made in natural science by a judicious use of hypotheses. Facts are accurately observed, or are gained by exact experiment, and are compared with facts; inferences are drawn, and are compared with other inferences, until a good working hypothesis is attained. From this hypothesis deductions are made which must necessarily prove true if the hypothesis be correct; the truth or falsity of the alleged facts is tested by an appeal to Nature; and so wider hypotheses are gained, each in turn being tested and tried by an appeal to facts, until, finally, that generalization is reached which includes in its expression so many and so varied phenomena that to it is given the name of a "law of Nature."

But notwithstanding the sure and tried foundations upon which each law of nature rests, phenomena ever and anon become apparent which refuse to be completely explained by any of these laws. Upon more careful examination, it may be found that such phenomena have been erroneously observed, and they may be brought under the application

of a known law, acting perhaps in a peculiar and even unprecedented manner. In such cases the phenomena cease to be residual phenomena.

But, on the other hand, some of the observed phenomena may resist every attempt made to explain them; they may refuse to retire from the list of established facts, and at the same time refuse to find their full explanation in terms of any well-established law. But, while so doing, these phenomena may also not be opposed to the law; they may not be contradictory to, but simply not wholly explainable by, any known law of nature.

Instances of the valuable results which have been obtained by the exact investigation of residual phenomena are numerous in every branch of natural science. One of the most striking is furnished by Newton's investigation of the atmospheric velocity of sound.

Newton showed that the velocity of sound in air might be calculated from certain theoretical considerations; a rough measurement of the actual velocity gave him a number differing very considerably from that which his theory required. Later and more exact experiments failed to explain the discrepancy, but in 1816 Laplace gave an explanation of the seemingly exceptional phenomenon, which not only sustained the theory of Newton, but also paved the way to the modern doctrine of the equivalency of heat and mechanical work. In the residual phenomenon which was left unexplained by Newton lay the germ of one of the greatest advances made by science in recent years.

Another striking instance of the value of residual phenomena is to be found in the history of chemical science.

From his experiments upon combustion, Lavoisier concluded that the peculiar properties of acids are due to the presence of the element oxygen in these bodies. But an undoubtedly acid substance was known (muriatic acid) from which no oxygen could be obtained. Here was a residual phenomenon—a phenomenon not absolutely contradictory of the law, that that group of bodies called acids is characterized by the presence of oxygen, but certainly a phenomenon demanding accurate investigation. Closer examination might have shown that the acid supposed to contain no oxygen was not really free from that element, or it might have led to the adoption of a higher generalization concerning the nature of the group "acids," or, lastly, it might have necessitated an entire alteration in the terms of Lavoisier's so-called law.

Chemists, however, for many years contented themselves with asserting that, as Lavoisier had pronounced oxygen to be the acidifying principle, and as muriatic acid was undoubtedly a true acid, this body *must* contain oxygen. But Sir Humphry Davy showed that an accurate examination of the residual phenomenon presented by muriatic acid led to a more extended and more exact knowledge of the nature of acids, and necessitated a change in the prevalent views concerning these bodies. The views of Lavoisier were found to express a truth, but not the whole truth; fresh incitement was given to research, and

fresh advances were quickly made in the knowledge of groups of compound bodies.

But there is another way in which the investigation of residual phenomena may aid, and has largely aided, the advance of scientific knowledge.

Phenomena, regarded as residual, have not unfrequently been shown to be completely explicable in terms of a known law ; and thus fresh light has been thrown upon the modifying influence exerted on the action of the law by the conditions under which the law acts.

The orbit of Lexell's comet was accurately determined; nevertheless, the comet failed to appear at the proper time. Here, surely, was a phenomenon which could not be explained by the law of gravitation alone : hypotheses, plausible and probable in themselves, were broached to account for the apparently exceptional phenomenon. But subsequent investigation showed that that appearance of the comet, from observations of which the orbit had been calculated, was due to the disturbing influence of one of the members of the solar system (probably of Jupiter) whereby the comet had been dragged within the limits of our vision, but that this visit to earthly spheres was altogether abnormal : the phenomenon presented by the visit of the comet was entirely explicable in terms of the law of gravitation.

What could be more opposed to our ordinary notions concerning the effects of heat than the fact that water should be frozen in a red-hot vessel ? But this phenomenon, apparently inexplicable in terms of any known law, upon exact investigation finds demonstrable explanation without recourse being had to the action of an unknown agent. The experiment is carried out by pouring liquid sulphur dioxide—a liquid which boils at a temperature lower than that of the freezing-point of water—into a red-hot platinum crucible, immediately adding a little water, and quickly turning out the ice which is produced.

Experiment shows that when a liquid is suddenly brought into contact with a highly heated smooth surface, vapor is evolved which surrounds the mass of liquid as it were with a screen through which the heat, radiated from the hot surface underneath, passes but slowly ; the liquid thus rests upon a cushion of its own vapor, and does not touch the hot surface beneath. The temperature of a mass of liquid in this (*spheroidal*) condition is lower than that at which the liquid boils. Now, as liquid sulphur dioxide boils at a temperature lower than that at which water freezes, and as immediately the liquid touches the heated platinum crucible it is partially vaporized, and the residual liquid is then floated, so to speak, upon the stratum of gas so produced, it follows that, so long as this condition is maintained, the liquid contents of the crucible are at a very low temperature; hence the temperature of the water coming into contact with this cold liquid is greatly reduced, and the water is frozen.

Exact investigation of this phenomenon, therefore, adds much to

our knowledge of the laws which govern the vaporization of liquids, and shows us these laws at work under peculiar conditions, while at the same time it brings the apparently exceptional phenomenon under the domain of a known law. Once more, the examination of residual phenomena may be, and has often been, of immense service to science, in freeing naturalists from the tyranny of an established theory which has for long been regarded as of necessity affording a full explanation of the entire series of facts to which it is applied.

The tyranny of orthodoxy is not unknown in science. The overthrow of that tyranny is one result of the investigation of residual phenomena.

During the greater part of the eighteenth century the theory of Phlogiston was all-prevalent in chemistry. According to this theory, when a body burns, it gives out a something called *Phlogiston*, the escape of this mystical something being the cause of the phenomena which attend the combustion.

This theory accounted in a fairly satisfactory manner for the greater number of the observed facts. One little fact, however, was scarcely explicable by the Phlogistic theory. So far as rough measurement went, the weight of the burned body appeared to be greater than that of the body previous to combustion. This residual fact was long overlooked, but the genius of Lavoisier forbade him to pass over so important a circumstance. By repeated and exact experiment, Lavoisier established the correctness of the residual phenomenon, and he showed that the phenomenon was inexplicable in terms of the commonly accepted theory.

Modern research has taught us that the fact firmly established by Lavoisier is not absolutely contradictory of a modified Phlogistic theory ; but Lavoisier's work necessitated a thorough revisal of the prevalent theory of combustion, and prepared the way for great advances which have at last enabled us to reconcile his theory with that of the Phlogisteans in modified form. Had Lavoisier consented to overlook the seemingly little fact that a body after burning is heavier than it was before, chemical science would probably have been for many years compelled to submit to the thralldom of the Phlogistic theory, which, in its then accepted form, barred the path of true advance.

When Galileo's telescope discovered to the gaze of the astronomer the satellites of Jupiter, did not those in authority protest most vehemently against the residual phenomenon ? Why ? Because they saw that this phenomenon could not be made to fit into the accepted cosmical theories of the day : not only was it inexplicable in terms of these theories, but it was absolutely opposed to them. Galileo, however, persisted, the phenomenon was more fully investigated, and the science of astronomy was placed upon a sure basis ; the reign of mere authority in scientific matters was brought to an end, and Nature was installed as the supreme adjudicator in all matters of scientific inquiry.

But the examination of residual phenomena may also help to free investigators from that tyranny which is exerted by a number of concordant results, all seemingly pointing to but one conclusion.

If experiment after experiment points to one conclusion, and if all, with the exception of perhaps a single residual fact, is in favor of this conclusion, it is hard to resist the temptation to ignore that fact, and adopt what, but for it, is apparently the true conclusion. But this method is not the scientific method. The fact must be examined. It may be that the outstanding fact is finally reduced within the sphere of the previously adopted hypothesis, or it may be that a new hypothesis is suggested which explains this and all the other phenomena.

The great Swedish chemist Berzelius carefully examined the properties of the compounds of a newly discovered element; he determined the chemical and physical characteristics of this element, to which he gave the name of Vanadium. The facts ascertained by the experiments of Berzelius formed a concordant series; so far as these experiments extended, everything appeared to be in keeping with the conclusions arrived at by him. But it was afterward noticed that the crystalline form of certain compounds of the metal vanadium was different from that required by the commonly accepted and, as it appeared, well-established theories concerning the connection between crystalline form and chemical structure. The examination, by Roscoe, of the residual phenomena presented by the crystalline forms of the vanadium compounds led to the astonishing discovery that the so-called metallic vanadium of Berzelius was really not an elementary body, but a compound of the true metal vanadium with oxygen. This peculiar oxide presents most of the physical properties of a metal; indeed, so metal-like is this oxide that the presence in it of oxygen was entirely overlooked, even by so careful a worker as Berzelius.

The researches of Roscoe threw a new light upon the chemical history of vanadium, and at the same time confirmed in a marked manner the law connecting chemical structure with crystalline form.

But, lastly, the study of residual phenomena may aid in freeing our minds from that fascinating, but surely erroneous, idea which a mere superficial acquaintance with natural science tends so much to strengthen, viz., that Nature is, and indeed must be, extremely simple.

The simplicity of Nature is a favorite theme with a certain class of would-be philosophers: it is a doctrine easily accepted, but a doctrine which has led to pernicious results.

Extreme instances of the overruling power of this idea may be found in the fascination exerted over minds, even of the highest order, by numerical analogies, that are really baseless. The seven colors of the spectrum were supposed, even by the great master himself, to have some mysterious connection with the seven tones of music. The number of the satellites of Jupiter added to the single satellite of the earth leaves but one satellite for Saturn, if the perfect number six is to be

made up; hence Huygens concluded that Saturn could have but one satellite.

When chemistry emerged as a distinct branch of science from the superstitions and conceits which had so long overshadowed her, the line of demarkation between chemical and mechanical action was made clear and unmistakable. On this side were ranged all phenomena purely mechanical; on that, all phenomena purely chemical. Nature's laws *must* be simple. One great fact was predicated of each class of phenomena—the distinction was a simple distinction. But as Nature's facts were more thoroughly searched into, phenomena were remarked which tended to discredit the extreme simplicity of the division into chemical and mechanical actions; those phenomena were passed by as too trivial for serious notice. But the residual phenomena at last forced themselves upon the attention of chemists; and one great result of the examination of these phenomena has been the discovery that the simple classification into chemical phenomena on that side and mechanical on this was too simple—was, in fact, an artificial classification; that there is no sharp line of demarkation in Nature, but that a series of facts exists which bridges over the gulf formerly supposed to be fixed between the two sets of phenomena.

The earlier study of biological science tended to show a great simplicity in the vital processes occurring among all living things; but the more advanced study of the same science has altogether overthrown the simplicity of the earlier scheme. Certain animals, and classes of animals, seem deliberately to adopt strange expedients for reproducing their kind, as if to warn us against such hasty generalizations. How should we have imagined the possibility of fertilization for successive generations, of hermaphroditism, or of reproduction by fissure, etc., being found among the methods which Nature adopts for replenishing the earth, had we contented ourselves with an examination of the comparatively simple methods of ordinary sexual reproduction?

The importance of residual phenomena is undoubtedly great; the difficulties which attend the study of these phenomena are likewise great.

A phenomenon, supposed to be residual, may be found on closer examination to be fully explained by some known law, acting either under ordinary or under modified conditions. Before, therefore, attempting to find a new hypothesis which shall explain the residual phenomenon, it is necessary to determine the fact of the phenomenon being truly residual. Of course, if an explanation be found for the seemingly inexplicable phenomenon without the necessity of introducing a new hypothesis, a distinct step has been made in scientific advance. If, however, the phenomenon refuse to be explained by any known law, a new hypothesis must be found, or the old must be modified so as to admit of an explanation being given for the hitherto inexplicable fact.

Of the new hypotheses which present themselves to the mind, which

shall be chosen? That which is clear and definite, and from which results can be deduced in a form which permits of their being tested by experiment.

If such an hypothesis be found, it then becomes necessary to ask, Does this hypothesis explain facts other than those included in the special residual phenomenon under consideration? An hypothesis which explains, or seems to explain, an isolated phenomenon, but which does not include other phenomena within its grasp, or which does not leap to the discovery of hitherto unknown facts, may be a true hypothesis, but it is certainly one which must be accepted with caution, and only provisionally until a better be found.

Finally, the new hypothesis must be in keeping with the well-established laws of nature. An hypothesis which contradicts any of these can not be accepted, although it may explain the special phenomenon to give a reason for which it has been called into existence.

The recent history of natural science furnishes many examples of the use of residual phenomena. Let me mention two only: one, in which an hypothesis has been suggested, proved, and adopted; another, in which the value of the hypothesis suggested is not yet finally determined.

It is well known that plants derive their support from the air and the soil; that support consists partly of mineral, partly of vegetable matter. But the curious fact was noticed that the leaves of certain plants frequently had adhering to them remains of insects or even entire insects. Following up this fact, Mr. Darwin and others have established the generalization that members of more than one species of plants derive their nourishment mainly from animal matter, and that these plants thrive better upon such food than upon the ordinary kinds of plant-food. Thus another thread has been added to the bond which visibly connects the animal and vegetable kingdoms.

The chemical elements have long been regarded as truly elementary bodies, that is, as bodies from which no form of matter other than themselves can be obtained. But phenomena presented by the spectra of certain of these elements seem almost inexplicable by the commonly accepted view. Mr. Lockyer has carefully examined many of the so-called elementary spectra, at temperatures varying from that of a gas-flame to that of the star Sirius, and, in order to explain the phenomena noticed, he has provisionally adopted the hypothesis that the so-called elements are really compound bodies. This hypothesis, whether eventually confirmed or refuted, suggests a large field for research to the chemist and to the physicist, from which neither can fail to reap most valuable results.

The observed residual phenomena of nature which yet await solution are many and varied; every branch of scientific work presents its own list. Let me glance at a few, and they shall be chiefly chosen from those phenomena which are investigated by the science of chemistry.

That the molecules of the elements, i. e., the smallest individual parts which exhibit the properties of the elements, consist of yet smaller parts, or atoms, is undoubted. The generalization holds, with few exceptions, that the elementary molecules contain each two atoms. The exceptions are exhibited by the elements phosphorus, arsenic, cadmium, and mercury, the two former being possessed of molecular weights four times as great as their atomic weights, while the molecular weights of the two latter are equal to their atomic weights. No conclusive explanation has as yet been given of this fact; it remains a true residual phenomenon.

Again, the atoms of the elements are possessed each of a certain definite binding power. Each is capable of uniting with a fixed maximum number of other atoms, but this binding power is not always completely exercised. Why does this power vary? How is its action modified by the conditions under which it is exercised? Can the known facts concerning the action of this binding power, or valency as it is called, be brought within the scope of any definite and workable hypothesis? These questions are to be solved by the researches of the chemists of the future.

Once more, the properties of certain elements vary considerably with variations in the conditions of those elements. Oxygen, when exposed to the action of the electric discharge, is not split up into any form of matter other than itself, nor does it combine with any other form of matter, nevertheless its properties are largely modified. The molecular weight of ozone—the new form of oxygen produced by the action of the electric discharge—is known to be one and a half time greater than that of ordinary oxygen. But, nevertheless, no complete explanation of the facts, of which this special fact is a representative, has yet been given. Allotropy remains a residual phenomenon in chemical science.

Many animal instincts, e. g., the curious instinct which prompts the cuckoo to lay a single egg in a nest not her own, connected as this instinct undoubtedly is with the similar but less perfectly developed instinct of the American *Molothrus bonariensis*, have not as yet been completely brought within the sphere of any wide generalization.

Why should the use of its sting inflict injury, if not death, upon the bee?

Why do variations in structure or function arise suddenly in various animals?

These questions, and many questions similar to these, await their full explanation.

Science advances by slow but sure steps; she carefully propounds hypotheses, and carefully marks off those phenomena which these hypotheses leave unexplained. She is aware that the phenomena occurring in that immense sphere assigned to her are not always to be explained by one, but often by many hypotheses. Phenomenon is

modified by phenomenon. Law reacts upon law. All she knows is lawful, but all is not yet intelligible. With patience and sure faith she advances to the goal ; the road is long, but the reward is great.—*Fraser's Magazine.*

THE "AUTOBIOGRAPHY" OF GEORGE COMBE.*

By ELIZA A. YOUMANS.

GEORGE COMBE has been dead twenty years, and his name is almost forgotten. Many of his teachings, which were bitterly opposed when he uttered them, are now quietly accepted. His theories of religion, of education, of the treatment of the insane and criminal classes, are more or less approved, and even the doctrine that mind is a function of the brain, which he was among the first to assert, and for which he was denounced as an infidel, has taken its place among the data of science. But the system of phrenology to which he gave himself with such intense devotion is discredited by science, and, like Mr. Combe himself, is now seldom heard of. There is much, however, in his biography to interest those who remember him, and who sympathized with his career as a reformer. But it is not to the biography at large that we now call attention, but to a fragment of autobiography which occupies the opening pages of the book, and embraces the period of his childhood and early youth. For, although he was born in another country (Scotland), and a former century (1788), yet the essential experiences of the home, the play-ground, and the school, were the same there that they are here, and the same then as now. Combe understood the conditions of well-being for both mind and body, and the far-reaching consequences of conduct. He had made his "bringing up" a matter of serious study, and he wrote this sketch, as he spent his life, for the good of others. We have found it by far the most interesting portion of a very ably-written biography. But, since we can not print the whole of it, we give that portion which treats of his education, with such explanations as are needed to make it intelligible.

For the benefit of our youthful readers, it may be well to state that from 1817 to 1836, while still practicing the legal profession, Mr. Combe kept up a fierce warfare in defense of phrenology and certain principles of right living, which he published in a work entitled "The Constitution of Man." This book had an immense circulation, and was translated into the leading languages of Europe. In 1837 he retired from his profession and gave the rest of his life to the dissemination of his principles. He traveled in England, America, and Germany, and

* The Life of George Combe, author of "The Constitution of Man." By Charles Gibbon. In two vols. London: Macmillan & Co., 1878. Price, $8.00.

lectured on phrenology, education, physiology, the laws of health, and the sources of the well-being of nations. He was a leader in the struggle for what he called secular education—that is, a training in such knowledge as applies to the duties of life—he advocated prison reform, and in 1857, the year before his death, he published a work "On Religion and Science," the product of much anxious labor and the "outcome of his life's thought."

Dr. Andrew Combe, brother of George Combe, and nine years his junior, was also a man of remarkable ability and force of character, and both the brothers had feeble constitutions, suffering all their lives from ill health. They agreed in the belief that their infirmities were brought upon them by the circumstances of their childhood. Andrew died in 1847, and his "Life" was written by his brother George, who made a point of exposing the unhealthful conditions to which his brother had been subjected in early life. But some of the relatives were unwilling that these family details should be published to the world, and so they were omitted from the biography. But, when George Combe afterward wrote a full account of the first sixteen years of his own life, the suppressed portion of his brother's biography was embodied in it, and this is the autobiography with which we are now concerned. It was natural, perhaps, that relatives should object to its publication; but certainly in no other part of the work before us are Combe's tenderness, sense of justice, and ability, better shown than here; for, while he tells everything frankly, he all the while impresses the reader with the upright, affectionate, and intelligent character of his parents.

We condense from Combe's account the following significant details: At the time of his birth his father was forty-two and his mother thirty years old. She was short, well-formed, quiet, energetic, decided, and sensible. She was accomplished in every practical art of housekeeping. She could milk, churn, make butter, wash, cook, spin, shape and sew clothes for both sexes; was active and methodic, and generally had her work done before dinner, and was ready to pay and receive social visits. She could read and could write her name, which was a fair literary education in those times. The father was six feet two inches in height, strong in trunk and limbs, with a large head, and perfect health. He wrote exellent sense and good composition, but was imperfect in grammar and spelling. He was painfully aware of these defects, and used to say he would rather hold the plow for a day than write a letter of a page in length. His over-consciousness in this matter "led him to educate his sons to the best of his ability and his lights." They had seventeen children. George was a well-formed, healthy child, and so far as character depends upon inheritance he had nothing to complain of.

The house where they lived stood close under the southwest bank and rock of the Castle of Edinburgh. The locality was low, and, while the windows looked upon gardens and corn-fields, the ground behind

was a filthy swamp in winter, and covered with dunghills in summer; tan-works and magnesia-works poured their refuse into open ditches of small declivity all around the place. The public drain from two humble localities of Edinburgh ran uncovered past the dwelling, and the house itself was connected with his father's brewery. A more unhealthy residence could hardly be conceived. The two-story house contained two rooms, a kitchen and bedroom on the lower, and three rooms and a very small bedroom on the upper floor. When Combe was about ten years old an additional room and bedroom were built. At about this time (1798) the family consisted of the parents, thirteen children, and the servants, all crowded into these small rooms. Combe says, "The conditions of health and disease were wholly unknown, the mind being regarded as independent of the body, and the constant sickness and many deaths in the family were never thought of in connection with these material surroundings."

Combe thought that if people only knew better they would do better; but after a lapse of eighty years, and with our abundant knowledge of sanitary science, it seems that in the public schools of New York to-day the conditions of health and disease are frequently no more thought of than they were in Edinburgh when Combe was a child.

It will be observed that, in telling us about his education, Combe all the while distinguishes sharply between his *real* education and his *nominal* education. His knowledge of mental science, such as it was, helped him to interpret his own experiences. The things he remembers are to him indexes to his natural gifts, as the strongest impressions would be made on his predominant faculties. By this means he discovers the emotional bias that shaped his life, in the incidents of a summer spent on his uncle's farm when he was three or four years old. His first remembered lesson was given him here by one James Reid, a young farmer who came often to visit his aunt and cousins. Combe says of him:

He was a clever, intelligent person, and fond of jokes and fun. He gave me a large red field-turnip, hollowed it out, cut a nose, mouth, and eyes in one side, put a candle within, and astonished me by the apparition of a human face with a dark-purple skin. He taught me to give myself a number of ridiculous names, such as Timothy, Peter, Baldy, Elshinder, and so forth; and for the sport which this afforded he gave me a halfpenny. The list was closed with the name "Scoundrel Grant" (the familiar name of a mean man in Edinburgh); and I observed that when I wound up by giving myself this appellation there was a loud shout of laughter from all the company. This hearty laugh led me to suspect something wrong in that name, and I stopped short at it. Mr. Reid tempted me with another halfpenny to complete the list, and I reluctantly uttered "Scoundrel Grant." The reward was given amid shouts of laughter, and for the first time I became conscious of conflicting emotions. I was as much ashamed of the name as I was pleased by the money, and when I was at length told what "Scoundrel Grant" meant no power on earth could induce me to give myself the name.

Another incident of this summer must be noted. He fell into a small rivulet, wet his clothes, and remained out while they dried. He caught a severe cold, and was sent home to die of consumption.

His school education began when he was five or six years old. The schoolroom was small, low in ceiling, and crowded with children. In the course of the summer his strength gave out. He says:

From nine to twelve I could see to read; but in the afternoon, from one to three, the letters were hazy and I could not distinguish them. I told the teacher my condition and was sent home. When I told the family why I left school there was great wonderment. My brother John thought I was shamming. He put pieces of wheaten bread and oat-cake of similar size and appearance before me and asked which was which. I could not tell. He then gave me the aid of my father's spectacles, and I at once named the crumbs correctly. He thought he had now caught me, for he said, "A young person can not see clearly with an old person's spectacles." I protested my truthfulness, and was mortified at being suspected of deceit. But my mother came to the rescue, and said she did not think I was feigning. She took me from school and put me to sea-bathing. In fact, there was nothing anomalous in my seeing with my father's spectacles: he was little past middle life, and they were of low power. I was probably as much debilitated in brain and eye as an aged man, and the spectacles might suit my condition as well as his. But it is difficult for me to describe the grief and indignation which the suspicions of the family roused within me.

He had a pleasant summer by the sea; the ships sailing up and down the Frith of Forth, and the fishing-boats which studded the water for miles were objects of vivid wonderment and interest to him.

His next schooling is thus described:

Mr. Campbell, who kept a school near by, taught me to read and spell after the fashion of those days; i. e., I spelled and pronounced the vowels without once dreaming that the words had a meaning. The idea that English words in a printed book were signs of feeling did not dawn upon me till years afterward. I knew only broad Scotch, and an English book was as unintelligible as a Latin book.

As to his religious education at this period he says:

I went regularly to church, but never understood one word of the sermon. This gave rise to a habit of inattention to spoken as well as written language. Whenever I was out of reach of my father's foot and hand I fell asleep, the refreshment of which was the only advantage of my church-going.

When he was six or seven years old he was again sent to the seaside, and left with a family of old people who had no sympathy with children. The months he spent there were full of wretchedness. He thus refers to them:

I slept on a "shake-down" in the garret, and the mice careered over me in the night. During the day I wandered in the harbor, but there were no ships in it; climbed the banks above the town, where were only corn-fields; built castles of wet sand and knocked them down again, all alone; and wearily, wearily did day pass away after day, bringing no change. I was a shy boy, or I might have found acquaintances in the street.

He was taken home in September, but such was the effect of the unwholesome position of his father's house, of its overcrowding, and of mistakes in his diet, that he had glandular swellings ending in suppuration. His brain was strong and active, and at school would blaze away for a few days until he was completely exhausted, when he would stay at home and lie on the sofa three or four days till the nervous energy was recruited. (These alternating periods of vivacity and exhaustion continued throughout his life.) He thus records an incident of his childhood, as an example of the influence which a passing observation of a sensible servant may exercise on the mind of an earnest, thoughtful child :

> About this time one of my mother's servants from whom I received sincere sympathy, observing my feeble condition, said, "O laddie, you should never marry." Young as I was, I understood her meaning, and her remark made an indelible impression on me.

The train of thought which, late in life, Combe gave to the world in his essay upon "Religion and Science" was started by an incident of his early childhood. When six or seven years old he was given a lump of candy. The nurse-girl asked him to share it with his brothers and sisters, which he did. The girl then assured him that God would reward him for it. When he asked her "How?" she told him God would send him everything that was good. Should he get more candy? he inquired. Yes the girl told him, if he was a good boy. Would the piece he had left grow bigger? "Yes," was the reply, "God always rewards the kind-hearted." So the remaining piece was carefully wrapped in paper and put in a drawer and left all night. The next morning he examined it with eager curiosity, but no change could be discovered in it, and he had the bitterness to find that he had been benevolent at his own expense. His faith in the reward of virtue received a shock, and it was a long time before he learned the true nature of Divine rewards for good deeds.

While still a child, he saw a man and woman walking near the verge of the highest part of Salisbury Crags. Soon an alarm was given that the man had pushed the woman over the precipice and she was killed. The man fled down the northeast slope of the hill and never was discovered. Combe says his imagination was haunted by the recollection of this scene; and he was terrified to go to sleep lest he should see the murdered woman's ghost. The belief in ghosts was universal in his juvenile circle, and a sore superstition it was, for he held "every belief to be as true as the most indubitable facts." Another striking event of his early boyhood awakened in him a sense of the mistakes of Government. Two sons of a poor widow, whom his father had helped, poured forth their gratitude in every form of kindness to his father's children. One of them had been to Greenland in a whale-ship and he delighted young George with accounts of the perils and excitements of whale-fishing. Paid spies of the press-gang gave in-

formation of his liability and his residence, and he was torn from home and friends and forced aboard a man-of-war. Combe says:

It is impossible to describe the horror and indignation with which this event filled me. It gave the first rude shock to my feelings of respect toward the ruling powers. I had worshiped the King and looked upon the Lord-Provost with reverence and awe. But this incident converted me from a loyal, trusting, Tory child, into a demagogue and reformer.

One day as he was walking along the road with one of his father's workmen they met a tall man, in Highland costume, with a huge cap and plumes, and a fearful-looking iron-hilted sword, who asked the workman, "Is this your son?" "No," said the man. "Is he a good boy?" "Yes, he behaves very well," said the man. "I am glad of it," said the soldier, laying his hand on his sword, "for it is my duty to cut off the heads of all naughty children." Combe says, "I believed every word of this assurance and for months dared not venture into the street without keeping an anxious watch for this sergeant who had filled me with unutterable horror."

These incidents may seem trivial, but they formed the staple of his practical education. He says that "great drifts of suffering were driven through the tenor of my life by the absence of consistent principle in the actions and teaching of all by whom I was surrounded." And it was the vivid recollection of this unhappiness which determined his career as a reformer.

At the age of nine he entered the High School of Edinburgh, where he staid four years. There were about one hundred boys in his class, and the learning was mere memorizing. The teacher, Mr. Fraser, every afternoon gave out lessons (Latin) to be learned for the next day. In the morning he began at the head of the class and heard each scholar repeat the portion of grammar he had learned by heart. Next came translation. The sons of rich parents had tutors, of evenings, who *taught* them, but Mr. Fraser *taught* nothing. These boys were at the head of the class, and with them the lessons went on smoothly; but, when the incapables were reached, "beating took the place of teaching." By standing from twenty-five to forty-five from the head of the class young Combe learned his lesson by hearing those above him read it, and in this way escaped beating, except when the teacher was disturbed by a noise; then, says Combe—

He held us all bound for each other's transgressions, and let loose upon us a perfect storm of lashes, and never ceased till he was fairly out of breath.

The discipline waxed severer as time passed on, and in the third year it reached its acme. In the spring of that year Mr. Fraser "stripped and whipped," to use his own expression, the boys at a great rate. I recollect one *day* seeing fifteen boys standing at a time in the middle of the floor with their breeches stripped down, and he taking hold now of one and now of another, threatening to commence the "whipping." These inflictions were uniformly accompanied by a phraseology in utter contrast to their real chaacter. When he called on a boy

to hold out his hand to receive a shower of palmies, it was—"Here, if you please, my dear." Whack, whack, whack; scream, scream, scream. "It is all for the good of your soul and your body, my dear." In the third year all this discipline appeared to him insufficient; and, after announcing, "I must try a severer rod of correction, my dears," he walked to a small closet in the school, opened it amid portentous silence, and brought out a short riding-whip, such as game-keepers are armed with, and with which in those days they lashed the hounds. It had a lash of knotted cord, and a short, thick handle, with an ivory whistle at the end; and with this "rod of correction" he commenced operations. The lash twisted around the hand, leaving red scores on the skin, and, where the knots struck, in some instances drawing blood.

All this torture was a substitute for teaching. There was not a map or illustrative object of any kind in the schoolroom; and only on two occasions during the four years did he ever, to my recollection, address a word to us beyond translation and grammar of the baldest description. The first of these exceptions took place when we read the description of the bridge erected by Julius Cæsar over the Rhine, given in his "Commentaries." Our teacher had, according to tradition, constructed a model of the bridge with his own hands, and was proud of it. The fame of its great interest had been transmitted from class to class for many years; and we counted the days which should bring us to "the brig." At last the closet was opened in profound silence, and the model brought out.

It was placed on a chair in the middle of the floor, and we began to read the description. As there were many technical terms, he helped us by explaining them, and with conscious pride pointed out each stake and beam as we proceeded, and showed us its connections and uses. The reading and expounding lasted for several days, during which all the lessons were better learned than usual, complete silence reigned, and not a blow was struck. We thought ourselves in paradise. But the model was removed, monotony recommenced, and the arm and "the tawse" were again employed to do the work of the teacher's brain.

The noise and inattention which provoked the teacher and led to much of this severity were the natural consequences of our condition. Fully half of the seats stood apart from the wall, and had no backs. In summer we sat on them from 7 to 9 A. M., from 10 to 12, noon, and from 1 to 3 P. M.; and in winter, from 9 to 11 A. M., and 12 to 2 P. M., without any intellectual occupation, except hearing the lessons repeated over and over again as they descended from the top to the bottom of the class. There was suffering from an uneasy position of the body, and nearly absolute vacuity of mind; and this at an age when every fiber of the brain and muscles was glowing with nervous activity. If physiology and the laws of mental action had been known in those days, everything might have been different. The silence, pleasing excitement, and general good behavior which reigned when we had an intelligible object presented to us, clearly indicated what was wanted to render us all happy; but the hint was not taken. In point of fact, there was no other rational knowledge adapted to the young mind in our teacher's brain: *ex nihilo nihil fit** was exemplified in his whole teaching; for the other instance of attention alluded to was due to the occurrence of a thunderstorm, which frightened us by its darkness and proximity. This led him to describe a previous storm of the same kind, which had ended by a thunderbolt striking the front of the Royal Infirmary, quite near to the High School of those days, and breaking the windows on that side. He gave

* From nothing, nothing comes.

us some account of the nature of a thunderstorm, and how after a terrible crash the danger is past; and thus sustained our courage till the clouds cleared away. No other items of general information, except these two, dwell in my memory as having been communicated during the four years of my attendance.

In 1798 or 1799 I was sent to Mr. Swanston's school, to learn writing and arithmetic. In winter I was in his school, and Mr. Fraser's from eight in the morning till 2 P. M., without any interval of repose; and in summer from 7 A. M. till 4 and often till 6 P. M., with only one hour, from 9 to 10 A. M., for breakfast. Add to this labor lessons to prepare in the evenings, a constant feeling of inanition, especially during winter, cold feet and thin clothing, with no object in the world in my lessons to interest me, and it may well be conceived how the state of sin and misery brought on man by the fall was to me a palpable, undeniable, experienced reality. A few explanations will throw light on the causes of these sufferings. Too much cerebral action, and a close, ill-aired bedroom, with three besides myself in it, made me in the morning low, listless, irritable, and without appetite. My mother had been taught that oatmeal-porridge and buttermilk were the best food for children for breakfast. The buttermilk was bought in large quantities from dairymen's carts in the street. Frequently it was not fresh when bought, and it daily became more acid when kept. To my delicate stomach it often tasted like vinegar, and I revolted at the porridge. In my mother's eyes this was fastidious delicacy of taste, and she ordered the porridge to be kept for my dinner. I received a penny to buy a roll for my mid-day sustenance. At that time the quartern loaf ranged from a shilling to twenty pence in price, and the penny roll was a small morsel for a young, hungry, growing boy. On going out, however, I bought the roll at the first shop—there was one close by my father's gate. I ate it dry, and had no more food till half-past two, when I came home to dinner. My mother was not so severe as she had threatened to be, for she gave me a dinner that I could eat; but she never failed to have the porridge served in the morning. In all this she was actuated by a sense of duty alone, for she was ever aiming at our welfare. Ignorance was the rock on which her kindest endeavors were wrecked, and she was not to be blamed for not knowing what nobody else in her rank, or, so far as I have yet discovered, in any other rank of life, then knew. The cold feet and thin clothing were the consequence of my own self-willed ignorance. She pressed flannel underclothing on me, but because it irritated my excessively sensitive skin I rejected it, and pleaded that it was good for me to learn to be hardy in my youth, to prepare for the trials and exposures of manhood: this was listened to, and the flannel was not forced on me. In the school, and in the West Church especially, in which in those days there were no stoves, I often sat chilled like an icicle, and my only surprise is how I survived so much irrational treatment and stupid conduct.

My constitution, which must have been originally strong, suffered permanent deterioration from all these injurious influences. The bones were imperfectly developed; and bent clavicles and a slight distortion of the spine, with chronic irritability of the mucous membrane of the lungs, were the consequences. The benches of the High School had no backs, but some of them stood close to the walls. I suffered greatly from inability to sit upright, during the long hours of confinement, on the seats away from the wall; and have no doubt that then and there the distortion of the spine was produced. I often abstained from getting up to the third "form" because the fourth stood next the wall and supported my back!

But his out-of-school education all this time went on apace. The narrative continues :

I always had an active life and pursuits out of school, when any leisure was left me. We had ample play-ground near my father's brewery. My brother Abram was only a few years older than I. He was very clever at all boyish games, tricks, and small mischiefs; full of fun; a builder of rabbit-houses, and keeper of rabbits; passionately addicted to brass cannons and pistols, and the use of gunpowder in all its forms; and I followed him, a willing pupil. There were a number of boys, sons of workingmen, living in the neighborhood, who formed our companions in play; but no boys of the genteeler classes were within our reach, the brewery lying close to Westport and Grassmarket, and far from the new town. I too built a rabbit-house, and bought a pair of rabbits, which soon had a numerous progeny. The procuring food for them and cleaning their house were occupations, and the warm attachment I felt toward them was a source of great gratification. On two occasions, however, I grossly mismanaged them—one culpably, the other through kindness ill-directed, but both leading to results from which I subsequently drew instruction. The first fault was neglecting to clean their habitation. Under the pressure of other duties I neglected this one, and merely covered over the old litter with fresh straw. In the course of time the female killed her young, and the buck was savage. This infanticide occurred again and again, and, true to the spirit of the age, I held up the slaughtered young before the mother's eyes and beat her well, but did not clean her bed. At last, when I resumed the discharge of my own duty, her aberration ceased; but at that time I saw no connection between my own misconduct and hers. Many years later the study of physiology revealed to me my sin, and carried instruction with it. The organism of the animal was injured and rendered miserable by the dirt, and nervous irritability, akin to insanity, was the result. This example I subsequently applied to the case of the human poor, and saw in the deleterious physical condition in which many of them habitually live the cause of some of their sufferings and crimes.

In the other instance, my compassion was moved by the supposed sufferings of my pets from intensely cold weather; and I obtained leave from my father to transfer them from the house I had built for them, with the earth for their floor, to a loft having a deal floor and thoroughly inclosed and roofed. It had only a glimmer of light through panes of thick glass inserted here and there among the tiles. To my great distress the rabbits grew sick, lost their hair; their eyes became impaired; they lost their appetite, and the buck became so miserable that I took him out to the garden, tied him to a stake, and tried my skill in marking by standing at a distance of fifteen or twenty paces and shooting him with my pistol loaded with a single ball. The ball broke his spine, and he uttered a piercing scream. The cry struck so deep into my moral nature that it overwhelmed me with pain, shame, and remorse at the time, and has never lost its character in my memory since.

Long afterward I discovered that these sufferings of my beloved rabbits were the consequences of my having, through mistaken kindness, placed them in circumstances at variance with their nature. The ground was their native floor; their fur protected them from the cold; and abundance of air and light, which they enjoyed in their habitation which I had made for them, were indispensable to their well-being: and these were all wanting in the lofts. The instruction I drew from these occurrences was that, without knowledge of the structure and functions of a living organism, and its relations to the natural ob-

jects to which it is adapted and which influence its conditions, the best intentions may inflict only suffering when pleasure is meant to be given; and that this holds as true in the case of human beings as in that of rabbits.

His father took a high Tory newspaper, and its chronicles were both intelligible and interesting. It was full of wars and rumors of wars, hangings, floggings, burnings, and slayings, and these were illustrated from time to time by doings in the town. He saw panoramas of battles, celebrations of victories, public floggings and hangings, and heard the running accompaniment of discussion among the workmen in his father's brewery. But the war was the great educator. He and his brothers had cannons of all sizes and sorts, and, as they grew up, pistols. Cartridges were given them, and they spent their spare pence for powder, lead, a bullet-mould, and a ladle. He says:

We kept the neighborhood in disquiet with the noise of explosions, and when it was found that we used balls there was fear that we should injure ourselves. And there was risk. I was firing at a mark on the inner side of the door of my father's garden, having locked it to prevent accident. The door was so thick that bullets lodged in it; but on one occasion I struck a knot which the ball drove out and made a large hole. No harm came, as no one was passing, but I quietly bought a piece of putty to fill up the hole and some brown paint to paint it over, and the evil deed was never discovered. I got a foot of the butt end of a common musket, mounted it on a stock and wheels, put it on an ale-cask, pointed it at a mark eighteen inches square supported on a stalk, and fired till I knocked it to shreds; but my crowning glory was the actual firing with my own hand of one of the great guns of the half-moon battery of Edinburgh Castle. I made friends with a bombardier who put the port-fire into my hand and gave the word "fire," and the welkin roared with the report of the gun. I was then not more than twelve years old, and to me there was grandeur in the exploit.

Then, again, in the neighborhood of the brewery were tan-works, currying-shops, an iron-foundry, a pump-maker's yard and a blacksmith's shop which he frequented, observing what was done in them and mastering the theory of their operations. He understood the business of the brewery, and all sorts of incidents constantly occurring afforded practical illustrations of the principles he had learned. In this way he added to his general intelligence and kept active his understanding, which was sent to sleep at school.

He had an intense love of nature, and of whatever displayed power and contrivance. He says of a dam-head where the water fell twenty feet:

I have stood in a pouring rain, thrilled with delightful emotion, gazing on the thundering cataract, for such it seemed to me. At a later period the falls of Niagara did not excite a stronger feeling of the sublime than did this waterfall of my childhood.

His four years of suffering under Mr. Fraser came to an end in 1801, and, when he left the class-room for the last time, he says:

I ran down the stair three steps at a time, in an ecstasy of pleasure; and on

leaving the yards turned round opposite the building and wished to God that I had the command of a battery of twenty-four pounders for a day to blow the school to atoms. For years after I left the school, when I saw my teacher coming in the street, I took the opposite pavement.

So much for the education that had been ordered and paid for. His estimate of his schooling for the next two years is equally interesting. From the High School he went to the University of Edinburgh. With his first teacher he studied geography and mathematics, but, as his capacity for learning words was slender, he forgot yesterday's lesson in learning to day's, while in mathematics the demonstrations he repeated evaporated as fast as they were learned. But for several months his sole fellow student in geography was a young sailor from the middle ranks, who was very profligate, though bold and generous, and he related to Combe the histories of his corrupt experiences. Happily, however, they had no allurements for the lad, and increased his knowledge without subverting his morals. Of his experiences in Dr. Hill's Latin class, he says:

I could not master the lessons, and had no assistance at home. As we were now young gentlemen, there was no corporal punishment, no place-taking, no keeping-in. Those able and willing to learn were taught, the rest were left unmolested, if they kept quiet and let business go on. The boys in my condition took back seats, and let the clever boys sit in the front ones next the Professor.

He and they went on harmoniously and successfully; Combe listened, and learned what he could. But he says:

I must record one great benefit I derived from the lax discipline of all my teachers in the years 1802–'3. In those years my brain got nearly a complete rest; and as I was growing rapidly this was an advantage which in its ultimate consequences counterbalanced my losses by habitual indolence. I had a conscience, and in all my previous attendance at school it urged me to do my best, and punished me with painful upbraidings when I sacrificed duty to pleasure, which was not often; and thus my nervous system had been kept on the stretch, my brain had been overtasked and my health and growth impaired. But in these two years my brain got a rest, for my conscience was to some degree involved in my general apathy.

We have no room for details of his Sunday training. Like all the rest of his so-called education it was unintelligible, burdensome, discouraging. He envied the cattle that had no souls, and he envied his brother Abram, whose light disposition enabled him to throw Calvinism to the winds, and make witty sarcasms and jokes out of the materials it afforded. In 1802 he lost a brother, ten months old, of small-pox, and in 1807 a sister just younger than himself, who had been ill for many years. These events excited and bewildered him, but the example of his parents taught him not to complain of sufferings "sent by the hand of God."

He says that about the year 1802–'3 he first became conscious of

the desire for fame, and used to shed tears of sorrow at the thought that this wish could never be gratified, as he had no special talent for any pursuit and his social position was also against him. He attributes this feeling partly to his natural temperament, and partly to his Latin studies, such as they were. During these years he taught his younger brothers and sisters for one hour each evening, except Saturdays and Sundays, for which his father paid him a small fee quarterly. As he had himself been taught almost nothing, he had a poor idea of his performances as a teacher, although his parents and pupils were satisfied with his efforts.

At the age of sixteen he had to face the question of a calling. He was feeble, delicate, shabby in appearance, with no conscious bias, but only the wish to live by honest industry. He was offered as an apprentice to a dealer in woolen cloth, flannel, and small wares, but the proprietor, he says, "took me to the door to obtain light to view me better, and turned me round and round: he then politely told my father that I would not suit." On the way to the shop of another cloth-merchant they met one of his uncles, who was told where they were going, and what had happened at the former application. This uncle now suggested to the father that they try the law, "For," said he, "you have given George a good education: we have a numerous connection in town, and there is no writer among us." The father was afraid they could not succeed with this idea, but it ended in his going as an apprentice for five years to a "writer to the Signet," one Alexander Dallas. He had to bring a certificate from Professor Hill, of his attendance at the college for two years. He was terribly alarmed lest Professor Hill should decline to do this because of the utter neglect of his studies during those two years, but was astonished at the close of the session to get the following document:

EDINBURGH, *April* 13, 1804.

That the bearer, Mr. George Combe, attended the Humanity class in the University of Edinburgh two years, and prosecuted his studies with great diligence and success, is attested by

(Signed) Jo. HILL, *Lit. Hum. P.*

Although this certificate gained him the place, the autobiography closes by explaining how completely his schooling had unfitted him for it. His first experiences in the study of law were extremely painful and mortifying. Some degree of independent judgment in the use of words was now required, and of this he was wholly destitute. He had to begin anew his literary education, but by unwearied industry and perseverance he at length aroused his dormant faculties and learned how to use them. Combe thought his helplessness was due to the fact that at school he was taught nothing; but children nowadays are rendered equally helpless by over-teaching. They get abundant instruction and but little education. Our youths leave school as incapable of independent thinking as was Combe himself. With all our boasted progress empty-headed teachers still abound, and the failure of

children in repulsive tasks is still punished, less grossly than but often quite as cruelly as ever. In Combe's time "children," he says, "were ordered to learn, and scolded and punished if they did not get their lessons." Does not this pretty fairly describe the present state of things? Most parents still think, with the elder Combe, that to educate is to send to school, and the experience of George Combe should do something toward dispelling this prevalent error.

SKETCH OF PROFESSOR W. D. WHITNEY.

WILLIAM DWIGHT WHITNEY was born at Northampton, Massachusetts, February 9, 1827. He received an academic education at Williams College, in the same State, graduating in 1845. On leaving college he became clerk in a banking-house, and continued in this employment for about five years, devoting his hours of leisure to the study of languages, but particularly of Sanskrit, the ancient language of India. In 1850 he visited Germany for the sake of enjoying the exceptional advantages afforded by the universities there for the pursuit of linguistic studies. For three years he attended in the Universities of Berlin and Tübingen the lectures of the foremost philologers and Sanskritists of the time, namely, Professors Bopp and Weber, of Berlin, and Roth, of Tübingen. In conjunction with Professor Roth, he prepared an edition of the text of the "Atharva Veda Sanhita," which was published in 1856 at Berlin. Whitney transcribed the text from the MS. in the Royal Library at Berlin, and collated it with the MSS. of the Libraries of Paris, London, and Oxford. In a second volume, which is in course of preparation, the editors will publish a translation of the work, with commentary, notes, and index. Since 1849, when he became a member of the American Oriental Society, he has distinguished himself among all his associates in that learned body by the number and the value of his contributions to its "Transactions," and his untiring efforts to promote the objects for which it was founded. He was Librarian of the society from 1855 to 1873, and has been its Corresponding Secretary since 1857. Of volumes v. to ix. of its "Journal," more than one half was contributed by him. He was in 1854 appointed Professor of Sanskrit, and in 1870 Professor of Comparative Philology, at Yale College, which chair he still occupies. In 1858 he edited, with notes, the republication of Colebrooke's "Miscellaneous Essays," which have principally to do with subjects connected with Sanskrit scholarship.

Besides contributing voluminously to the "Journal" of the American Oriental Society, he is the author of several critiques and essays published in sundry journals, American, English, and German. Among

the more important papers either written or edited by him, and published in the "Journal," may be named Rev. Ebenezer Burgess's translation of the "Sûrya-Siddhânta" (a Hindoo treatise on astronomy) 1860, with notes and an appendix; text, with notes, of the "Atharva-Veda Prâtiçâkhya" (1862); the text of the "Taittirîya Prâtiçâkhya" (1871), with English version, notes, and native commentary, the last two being grammatical treatises—the edition of the "Taittirîya" won for Professor Whitney from the Berlin Academy the Bopp prize—reviews of Lipsius's phonetic alphabet and of the opinions of Biot, Weber, and Müller on the lunar zodiac of India, Arabia, and China. He was a contributor to the great Sanskrit Dictionary of Böhtlingk and Roth (St. Petersburg, 1853–'67, seven volumes). In 1869 he aided in founding the American Philological Association, and was its first President. His work, "Language and the Study of Language" (2 vols., 1867, republished in 1874), was made up of a series of lectures, delivered first at the Smithsonian Institution, Washington, and repeated at the Lowell Institute, Boston; it was translated into German, and edited, with additions, by J. Jolly, under the title of "Die Sprachwissenschaft" (Munich, 1874). His principal contributions to the "Journal of the American Oriental Society," "The North American Review," "The New-Englander," and other periodicals, were collected and published in two volumes, entitled "Oriental and Linguistic Studies" (1873–'74). To the "International Scientific Series" he contributed a volume in 1875, entitled "The Life and Growth of Language," which was very favorably received both at home and abroad, having been translated into French, German, and Italian. He has prepared several school manuals for the use of students of the German language, viz., a grammar, a reader, a dictionary, and texts of certain of the German classics. In 1877 appeared his work, "Essentials of English Grammar." He has now in press, in Leipsic, a Sanskrit Grammar, in English and German editions.

We append a list of papers published at various dates by Professor Whitney, but not contained in either of the two collections named above: "Material and Form in Language" (1872); "*φυσει* or *θεσει*"—"Natural or Conventional" (1874); "A Botanico-Philological Problem" (1876). The foregoing were published in the "Journal of the American Philological Association." Peile's "Greek and Latin Etymology" (1873–'74; "Transactions of the London Philological Society"); "On the History of the Vedic Texts" (1854; "Journal of the American Oriental Society"); "Contributions from the Atharva-Veda" (1856; in the same journal); on Lipsius's "Standard Alphabet" (1862; the same); "On the Jyotisha Observation of the Place of the Colures and the Date derivable from it" (1864; "Journal of the Royal Astronomical Society," London); "Are Languages Institutions?" (1875; "Contemporary Review"); "Müller's Rig-Veda and Commentary" (1876; "New-Englander"); "The value of Linguistic Science to Ethnology" (1867; in the same).

CORRESPONDENCE.

ON THE FEAR OF DEATH.

To the Editors of the Popular Science Monthly.

AN interesting article entitled "The Fear of Death" appeared in "The Popular Science Monthly Supplement" for December. The author in one place says: "At any rate the feelings with which we contemplate the termination of our own earthly life must vary indefinitely in different individuals, and in the same individual at different times; and it would be a matter of deep interest to compare our respective experience if we could bring ourselves to do so." Having been myself quite recently very near to the entrance of the "valley," and having been for a long time in the daily habit of mentally viewing the question of the extinction of life, it has occurred to me that, where the subject is one in which we all have an interest more or less, even my small experience may be in some degree useful and suggestive.

When quite young, too young in fact to have any definite idea of what death means, I had an extreme dread of the very thought. At the age of six years I stood for the first time in the presence of death, having been brought into the room to see the body of a deceased lady who had been very kind to me. I was awe-stricken. I could not imagine what had occurred. I was told in a subdued voice that she was dead. I did not understand it; I only saw that some terrible and to me inexplicable change had taken place in my friend, and for a long time afterward the mention of death filled me with childish horror. The thought that I too should one day be like that was unbearable.

In early manhood I had a reluctance to think on the subject of death at all, and whenever the repulsive idea presented itself I dismissed it as quickly as possible.

On one occasion, when about twenty-one years old, I accompanied, merely as a spectator, a military expedition against the Taiping rebels in China. During the space of an hour or so I found myself under fire, and, being a novice in the business of war, I felt decidedly uncomfortable. If freedom from apprehension of personal danger constitutes bravery upon such occasions, then I was not by any means brave. But during the whole time I was not conscious of any anxiety as to death or what may follow it; my chief thought was: "If I am hit, what will be the sensation? will it be very painful?" The paramount solicitude was for my *body*, and if my general anxiety included any other elements than the fear of *pain*, certainly that was the predominating one. Being only a looker-on, and having no active duties to occupy my mind, I remember distinctly my feelings upon that occasion.

Again, later on in life, I was caught in a heavy blow one night on our Southern coast. The vessel, a small schooner, was in ballast, and we were drifting rapidly to leeward toward the shoals which line the part of the coast where we were; we missed them by the merest chance.

All through that night the thought of death was present in my mind, my anxiety increasing with every cast of the lead, which showed the constantly lessening depth of water. Yet here, again, the fear of the *manner* of death was stronger than the fear of death itself. Of course, there were feelings of sadness connected with the thought of being cut suddenly off from relatives and friends, but still the chief apprehension was concerning the hopeless and seemingly inevitable struggle in the breakers before death should supervene.

As I approached middle age, the subject of death and what may possibly succeed it began to form more and more a part of my studies and to occupy more constantly my thoughts. The difficulties in the way of an unquestioning belief in a future state of existence beyond the grave increased the more the subject was studied, but the fear of death was if anything lessened. I was told that sickness and the approach of death would alter my views in that respect, and at last I began myself to have a curiosity to learn whether such a result would really follow upon the loss of health.

Not long ago I had a very severe illness, from which I have not yet quite recovered, and perhaps never shall. For a time my chances of life were very small, and I realized my condition perfectly; yet, the nearer Death approached, the less grim and repulsive he appeared. The principal feeling was one of resignation, or perhaps some would prefer to call it apathy. There was, however, always present with the idea of death a certain curiosity as to how the change would be effected, and what it would be followed by—whether by annihilation of all sensation, or by an extension of consciousness of identity with a higher development of faculties and perceptions. While the latter conception was the more pleasing, truth compels me to say that the former appeared to be the more probable.

The difficulty of making a mental presentment of a state of conscious identity

apart from the body and brain seemed insuperable, and to believe sincerely and without a doubt that which is inconceivable is, at least in my own case, impossible.

Doubts regarding the question of immortality gave me no concern as to consequences. Those doubts are honest, and I can not prevent them. I was and am convinced that if what I was taught in my youth concerning God and a future life be true, an All-wise and All-just Supreme Being can not condemn me for believing according to the best light of the intellect which he himself gave me; while, if the doctrine of immortality be false, then of course death ends all. In either case there is no cause for uneasiness. Since my partial return to health, the wish to live has strengthened; in fact, now that I am able to attend to my daily business, the state of my health gives me more concern than it did at a time when I was too weak to walk across the floor. On the whole, I think that the fear of, or rather the repugnance to death, varies directly with the vicissitudes of health—strongly developed in robust health, decreasing gradually as death draws nearer. It is well that it is so.

J. J. F.

New York, *December* 22, 1878.

EARTHWORMS, Etc.

To the Editors of the Popular Science Monthly.

I had the good fortune during the past summer to witness a remarkable display of reason, or something quite akin to reason, in an earthworm. I was watching a number of them in my garden after a shower, as they swallowed bits of dry grass and leaves, when I observed one of very large size take hold of a stick about six inches long. He took hold as he reached it, by the middle, and drew it toward his hole. But as the dirt was heaped up near the hole, the stick soon became bedded about an inch, and then resisted the persistent efforts of the worm to draw it farther. He then deliberately let go of the middle and felt along to the end of the stick, which he seized and drew easily to his retreat. I watched until it had partially disappeared in the hole, but was unable to determine the special value of the prize. It is likely that he desired to feed on the decayed bark of the stick, as I have observed that these worms almost invariably eat dried food instead of green.

By the way, have you ever had your attention drawn to the circulation of the *Caladium esculentum?* You will observe at the tip of a thrifty-growing leaf, on the upper side, a small hole, in which you can insert the point of a pin. Now water the plant abundantly, and shortly you will observe a small globule of water leap out of this hole. Nine of these combine to make a drop, which falls off and is replaced by another. In a short time quite a pool of water will be found under the plant.

E. P. Powell.

Clinton, New York, *January* 20, 1879.

EDITOR'S TABLE.

MORALITY AND EVOLUTION.

It is announced that Herbert Spencer has ceased writing upon his "Sociology," and begun the "Principles of Morality," the last of his series; and it is inferred from this that, having found his "Synthetic Philosophy" overgrown and unmanageable, he has abandoned a part of it in order to finish the rest. This is an entire misapprehension. He has never had his great work so completely in command as now. His suspension of labor upon the sociological division is but temporary, and he anticipates a part of the final ethical discussion for reasons quite other than those assigned. The step has been taken in consequence of Mr. Spencer's uncertain health, and from an apprehension that he might break down before reaching its concluding part. Regarding "The Principles of Morality" as the most important portion of his undertaking, to which all the preceding works are preliminary, he felt it to be of great importance to prepare such a statement of his ethical views as will show the bearing of the previous parts of his system upon that subject. He accordingly some months ago stopped work upon the second volume of the "Sociology," and began "The Data of Ethics," the first portion or groundwork of "The Principles of Morality." This is now so nearly finished that it may be expected to appear in a small volume of two hundred and fifty pages in the course of the spring, when Mr.

Spencer will resume the course of his labors upon "The Principles of Sociology."

The appearance of a new book upon morals is now so common a thing as in itself to be hardly noteworthy. But the publication of such a work, at the present time, by the most eminent expositor of the doctrine of evolution, and the only man who has dealt with that doctrine as the basis of a comprehensive philosophy which is broadly founded upon the results of modern science, and treated throughout with reference to the ultimate establishment of the principles of right and wrong in human conduct—such a book will be certain to attract wide attention.

Morality, as is well known, is a subject that has been hitherto kept in very close connection with theological beliefs. It has been generally taught by the dogmatic method, and as based upon supernatural sanctions, so that the theologians have come to be regarded as its legitimate custodians. Not only is the inculcation of morality a conceded prerogative of the pulpit, but the regular teaching of it, in nearly all our higher education, is also in the hands of the divines. In an interesting and instructive paper published in "Mind,"* by Mr. G. Stanley Hall, on "Philosophy in the United States," the writer remarks of the three hundred non-Catholic colleges in the country as follows: "In nearly all these institutions certain studies, æsthetic, logical, historical, most commonly ethical, most rarely psychological, are roughly classed as philosophy, and taught during the last year almost invariably by the president." To this it may be added that the president is almost invariably a doctor of divinity. These theological expounders of studies "most commonly ethical" ever insist upon the vital interdependence of theology and morals. It is taught that they are bound up together indissolubly and are subject to a common fate, and this is the way the subject is regarded by the great mass of people in the community.

But we are now called upon to take into account a most important fact. There is an undeniable and widely spread decay of theological dogmas affecting all classes of society. The old adherence to traditional beliefs is weakening, and men are falling away from their creeds. The ancient sphere of belief and faith is invaded by science, and is being inexorably circumscribed. This is notorious, and is acknowledged by eminent religious authorities.

In a paper of remarkable candor and significance, by the Rev. Phillips Brooks, of Boston, in the March number of the "Princeton Review" on "The Pulpit and Modern Skepticism," the writer admits that the phenomena of doubt "are thick around us in our congregations, and thicker still outside our congregations, in the world." This skepticism he recognizes as "a very pervading thing. It evidently can not be shut up in any guarded class or classes. Life plays upon faith everywhere. Ideas change and develop in all sorts and conditions of men; and the occupants of pulpits have their doubts and disbeliefs as well as others." Again, "a large acquaintance with clerical life has led me to think that almost any company of clergymen, gathering together and talking freely to each other, will express opinions which would greatly surprise and at the same time greatly relieve the congregations who ordinarily listen to these ministers."

And again: "How many men in the ministry to-day believe in the doctrine of verbal inspiration which our fathers held, and how many of us have frankly told the people that we do not believe it, and so lifted off their Bible's page the heavy cloud of difficulties and inconsistencies which that doctrine laid there? How many of us hold that the everlasting punishment of the wicked

* Reprinted in "The Popular Science Monthly Supplement," New Series, No. 1.

is a clear and certain truth of revelation? But how many of us who do not hold that have ever said a word to tell men that we thought they might be Christians, and yet keep a hope for the souls of all God's children?"

Dr. Brooks remarks still further: "There must be no lines of orthodoxy inside the lines of truth. Men find that you are playing with them and will not believe you even when you come in earnest. I know what may be said in answer. I know the old talk about holding the outworks as long as we can, and then retreating to the citadel, and perhaps there has hardly been a more mischievous metaphor than this. It is the mere illusion of a metaphor. The minister who tries to make people believe that which he questions, in order to keep them from questioning that which he believes, knows very little about the certain workings of the human heart, and has no real faith in truth itself. I think that a great many teachers and parents now are just in this condition. They remember that they started with a great deal more belief than they have now. They have lost much, and still have much to live by. They think that their children, too, must start believing so much that they can afford to lose a great deal and still have something left, and so they teach these children what they have themselves long ceased to believe. It is a most dangerous experiment."

We have quoted these frank and impressive passages because they will have weight as coming from a distinguished religious teacher. They reveal no secret, and state nothing that observing persons did not know before; but they bring out clearly the degree to which religious dogmas are already discredited and secretly abandoned, and they painfully illustrate the insincerity and duplicity that have resulted.

But what we have here to note is simply the acknowledgment of the extent to which theology is losing its hold upon the general mind, and untenable articles of religious faith are being abandoned. It is this crumbling theological system that has been hitherto offered us as the foundation of morals. Religion and morality, as we have said, are held to be bound up in a common fate, and to the great majority of people religion means orthodox theology. These will therefore naturally think that, when their articles of faith are discredited, morality must be discredited also. We are thus forced by the critical exigencies of thought to meet the question, Is morality to fall with the decaying authority of supernaturalism, or does it really rest upon another and more immutable foundation? In fact, the broad issue is, Does morality belong to the domain of theology or to the domain of science, and is it to be treated by theological methods or by the methods of science? Answers to these questions are now imperatively demanded.

It may be objected that this is an empty requirement, as we already have a distinctly recognized ethical science cultivated by rational methods—the utilitarian system, based upon experience, and rejecting all theological implications. It is true that there is a strong tendency of thought in this direction, but it is neither the prevailing mode of viewing the subject, nor does it make any claim to be based upon the results of modern science. Mr. Sidgwick's recent book, "Methods in Ethics," in which he undertakes to examine and criticise the grounds of ethical systems, does not deal with the relations of modern science to the subject, and in this respect it was disappointing to many. Those familiar with the drifts of recent inquiry perceive that the course it has taken and the results it has attained must profoundly affect the philosophy of morals, if indeed they do not give us a "New Ethics"; but Mr. Sidgwick seems but little more conscious of any such movement than were Bentham and Mill. He is not of course to be blamed, as he deals with past systems, but his work is proof that no close relation between

general science and ethics has hitherto been systematically traced out.

The most far-reaching and radical revolution in thought of which we have yet had experience consists in the extensive acceptance of the doctrine of evolution. That this doctrine has fundamental relations with morality is undeniable. Those theological teachers who hold that religion and morality are so unified that they must stand or fall together are fond of insisting that evolution is fatal to both. This is very much like a desperate abandonment of both to destruction, for the theory is making headway at a rate unprecedented in the historical growth of opinion. It has been developed by studious scientific men, and promulgated like any other scientific conclusion to which they have been led by the established processes of investigation and the established rules of logic. All our science is pervaded by it, and there is no hope that it can be arrested. It is therefore important to know what it is going to carry away, what it is going to leave, and what it is going to give. Will it subvert morality, or will it lead to a higher morality?

The answer to this question we can not regard as doubtful. If evolution be true, and man's ethical nature is no exception to the general constitution of things, then evolution is the agency that has developed morality in the past and brought it to its present condition. Assuming that the principles of right and wrong and the laws which regulate human conduct are rooted in the natural order, the sciences of nature which explain that order must have close bearings upon the philosophy of human conduct, while the profoundest interpretation of the method of the universe that has yet been attained, and which throws a flood of new light upon the nature of man and the development of humanity, must certainly aid us in the study of human activities in their highest aspects.

At any rate, we desire to have a report upon the present state of knowledge on this important subject, and we want it from a man authorized to speak. Mr. Spencer's book on "The Data of Ethics" may be expected to give us the scientific groundwork of the subject in connection with the principle of evolution, and it can not fail to prove helpful to many minds, both by the instruction it will afford and by the solicitude it will dispel in the present state of transitional opinion.

THE LATE DANIEL VAUGHAN.

We print this month the last of a short series of very interesting articles on astronomical subjects by Professor Daniel Vaughan, of Cincinnati. Before we had received from him the corrected proofs of the last article, news came that he was dead. We were of course startled by this intelligence, as his death is a profound loss to American science, and we knew that he was by no means a very old man, and were not aware of his failing health. But there now come to us certain painful disclosures regarding his life, of which it is desirable to take notice.

Daniel Vaughan was born in Ireland, of wealthy parents, about the year 1821. He had a good education from a tutor, and at the village school, and was noted for mathematical ability. He came to this country at the age of sixteen, and went directly West, becoming the teacher in a country school in Bourbon County, Kentucky. Here he studied in seclusion, and made great proficiency in the higher branches of scientific study; but, famishing for books and intelligent associations, he went to Cincinnati twenty-five years ago, mainly attracted by its library privileges. He now pursued a wide course of scientific inquiry with great vigor and enthusiasm, devoting himself mainly to astronomy and to the larger aspects of natural phenomena, which he treated with the freedom and independence of a strong orig-

inal thinker. He was master of the German, French, Italian, and Spanish languages, and also of ancient and modern Greek. He wrote one or two volumes upon mathematics and astronomy, and contributed numerous papers to the proceedings of learned societies, and to scientific periodicals at home and abroad. An example of the wide range of his studies and publications is afforded by the following list of papers and articles which appeared at different times and in different publications:

"The Doctrine of Gravitation," "The Cause and Effects of the Tides," "The Rings of Saturn," "The Light and Heat of the Sun," "The Origin and the End of the World," "The Advent and Appearance of New Stars," "The Asteroids," "The Nebular Hypothesis," "The Secondary Planets," "The Plurality of Worlds," "Stellar Astronomy," "Meteoric Astronomy," "The Remote Planets," "The Moon," "Earthquakes," "Volcanoes," "The Deluge," "The Sources of Power accessible to Man," "The Distribution of Metals," "The Geography of Disease," "The Abuses of Science," "The Absence of Trees from Prairies," "Surface Geology," "The Primitive Earth," "The Ancient Atmosphere," "The Silurian Strata," "The Carboniferous Formations," "The Origin of Lakes," "Origin of Mountains," "The Causes of Rain, Winds, and Storms," "History and Nature and Uses of Electricity, its Agency in Nature," "Galvanism," "Magnetism," "Ocean Currents," "The Life of Newton," "Of Laplace," "The Physics of the Internal Earth," "Determination of Planetary Distances," "Geographical Advantages for National Ascendancy," "Physics of the Internal Earth," "Discovery of Neptune," "Revelations of Spectrum Analysis," "The Theory of Probabilities in the Detection of Crime," and "The Catastrophes in Celestial Space."

Professor Vaughan was a correspondent of various eminent scientific men abroad, who had a high opinion of his abilities, and many of his papers were translated into the Continental languages.

One might suppose that so learned and accomplished a man, whose name gave distinction abroad to the great city of his adoption, would have been favored and honored by its intelligent and public-spirited citizens, and placed in a position so independent as to afford the best play to his remarkable powers. There is wealth to squander in Cincinnati on all projects and in all ways, as becomes a boasting city of the West in hot rivalry with St. Louis and Chicago, so that one would think it might fitly have taken decent care of its most illustrious scientific man. But it turns out that Professor Vaughan was most scandalously neglected; he led a life of pinched privation, was left to get a precarious subsistence by private teaching, and was cheated out of his earnings by the colleges in which he lectured and who got the benefit of his eminent name. We do not like to say that Professor Vaughan literally starved to death in Cincinnati, but he led a life of suffering and want, which the past inclement winter brought to a close in a hospital, and we are told that "an autopsy revealed the wreck of his vital system and proved that the long and dreadful process of freezing and starving had dried up the very sources of life."

We gather the main particulars here given from an article in the "Cincinnati Commercial" of April 7th, written by Mr. William M. Corry, a friend of Professor Vaughan, and subjoin from his communication the following extracts:

For years some kind woman, whose name we are sorry not to know, boarded and lodged Professor Vaughan, and gave him more sympathy than he got from all the rest of the town, and more also of substantial support. He was always sure of a pleasant reception at her humble home, and was not required to be punctual in his settlements. The boarding-house was broken up a year or two ago, and our poor friend was the worst sufferer. He took a room which was cheap, but every way cheerless, inaccessible, and uncomfortable. A chair and a bedstead with a pile of rags, a worn-out stove, and an old coffee-pot, with a few musty shelves of books, covered with soot, were all his fur-

niture. He lived, sick and feeble and old, from hand to mouth, often unable to go abroad for food, and as badly off for helping himself indoors. It were bad to have any human being so utterly abandoned, and so suffering. Here and there, at wide intervals, there was a man or woman who would have done much to modify this misery, but it ought never to have been left to those who could scarcely afford to curtail their own allowance of plain clothes and victuals for another.

His arduous literary labors were performed without any compensation whatever. (It may be said in this connection that he has recently been paid to his satisfaction for several essays over his name in "The Popular Science Monthly." A most pathetic incident of the last one is that, the very day before his death, he sat upon his bed and corrected the proofs, which ought to have been done for him, but which he would never ask any one to do, and which, if it did not cost him his life, without doubt shortened his few remaining hours.)

Mr. Corry indignantly adds: "There can be no doubt that the city has incurred a deep and lasting reproach by permitting such a treasure to be destroyed prematurely by disease and actual want, and that she should be told of it, and should suffer the consequences."

There is, however, this palliation for the conduct of the Cincinnatians. Professor Vaughan was modest, shrinking, and unobtrusive, and kept his miseries to himself. "He would not give his address to his friends, nor permit them to ferret him out and ascertain with their own eyes his actual condition. Nor would he make any explanation, much less ask or accept any pecuniary assistance." That is, he did not choose to submit to the mortification of becoming an object of charity. No doubt there were plenty of people who would have given alms, if it had been solicited, but the man's self-respect would not permit the degradation. It is said he neglected himself, and his townsmen merely imitated his example; but this is rather a cold-blooded apology for leaving a man of genius to penury, rags, and starvation. Read over the list of subjects upon which he thought and wrote, and read the first paper in this "Monthly," which shows the quality of his work, and then say how much vigor a man would have left to fight his Cincinnati neighbors in the competitions of money-making. He was incompetent to make money by his very vocation, and this must have been perfectly well known. Why was not a proper place made for Professor Vaughan, in which he could have given his services to the public, and been so fairly paid for it that he could have lived in a way to favor his best work? The answer is, that there was not sufficient appreciation of science among the people; and very likely, if by special exertion he had been put into a comfortable place, some miserable mountebank who knew better how to manage the public would have got the position away from him.

LITERARY NOTICES.

Cooley's Cyclopædia of Practical Receipts and Collateral Information in the Arts, Manufactures, Professions, and Trades, including Medicine, Pharmacy, and Domestic Economy: Designed as a Comprehensive Supplement to the Pharmacopœia and General Book of Reference for the Manufacturer, Tradesman, Amateur, and Heads of Families. Sixth edition, revised and partly rewritten by Richard V. Tuson, F. C. S., Professor of Chemistry and Toxicology in the Royal Veterinary College. Vol. I. New York: D. Appleton & Co. Pp. 896. Price, $4.50.

The rapid development of the practical arts in all directions in recent years has made it lively for the book-makers, because no sooner is a formidable treatise finished on these subjects, no matter with what painstaking care to bring it up to date, than it quickly falls behind, and the author has to set himself to work to prepare for the inevitable new edition. Time is but the register of change; change brings improvements, and improvements antiquate cyclopædias. And so it begins to be understood that no literature is so perishable as that which deals with facts and solid reali-

ties. This would be discouraging for book-makers and book-sellers, but for the circumstance that the old editions become soon worthless, and new ones indispensable. And it would be hard on the book-buyers, but for the fact that the new improvements are often so invaluable as to be cheap at almost any cost. We can not stop the growth of the arts in order to keep the treatises that we have bought perennially fresh.

Cooley's "Cyclopædia of Practical Receipts" is a work of high reputation, not only for its comprehensiveness and accuracy, but because it has been kept faithfully up to the times by its successive revisions; and a careful examination of the sixth edition shows that its standard of excellence has been strictly maintained. The title "Receipts" is in some respects unfortunate, as the work is by no means a mere receipt-book, and it makes no clap-trap claim on the ground that its receipts can be counted by the thousand. It abounds in important practical information of general interest in reference to the materials furnished by commerce and used in the arts, their preparation, and their purity, and is very full in illustrated directions for carrying on manipulations, and preparing numerous articles and products of general utility. The work is important to the chemist, the mechanic, the manufacturer, and the householder. It will be completed in two volumes, and the second may be expected to appear in a few months.

Health, and how to promote it. By Richard McSherry, M. D., Professor of Practice of Medicine, Maryland University, President of Baltimore Academy of Sciences, etc. New York: D. Appleton & Co. Pp. 185. Price, $1.25.

Dr. McSherry has here made both a readable and a useful little manual of hygiene. He has no hobbies, and does not profess to be the author of any new theories for the preservation of health, but he goes over the general ground of its conditions as affected by education, as related to the sexes, and as influenced by clothing, exercise, diet, and the habitual use of stimulants. Upon these topics there will be found much fresh information, with many judicious extracts from the best authorities, derived from wide and critical reading. The author's pages are enlivened with many personal references, and interspersed with acute observations calculated to please as well as to instruct the reader. The book will well repay perusal, and we heartily commend it.

After Death, what? or, Hell and Salvation, considered in the Light of Science and Philosophy. By Rev. W. H. Platt. San Francisco: H. Roman & Co. Pp. 209.

This is decidedly a lively volume. It is a sort of colloquial symposium; that is, it undertakes to present both sides of a controverted subject, or some of the issues of religion and science. Yet it differs from the symposium proper, in that the discussion is carried on conversationally, and still more that both sides are represented by one partisan. The book is written by a clergyman, and takes the form of a debate between a preacher and a skeptic. The skeptic seems a kind of poor stick, made to order for the convenience of the preacher, who cuffs him about in a very unceremonious way, and finally "converts" him.

The theory of the origin of the book we are half inclined to infer may be something like this: Rev. W. H. Platt is Rector of Grace Church, San Francisco, which is no doubt a sound and we trust a prosperous orthodox establishment. It is quite likely that, in that city of hoodlums, Chinese pagans, and wicked doubters, some graceless persons have poked fun at the Grace Church people about their antiquated, superstitious notions of hell. Now, even the regenerate are liable to suffer from lingering remnants of pride, and do not like to be made fun of; and so, we may suppose, they turned to their shepherd, Rev. W. H. Platt, for protection. Whereupon, it may be further assumed, he rose in some wrath and resolved to give these scoffing skeptics more scientific hell than they had ever had of the theological sort. We vaguely conjecture this situation from the first paragraph of the book: "The scientist boldly asks the preacher why he continues to preach the old-fashioned hell. 'Do you not know,' he says, 'that intelligent people now laugh at your lake of fire and brimstone, your devil with horns and dragon-tail, and all that sort of stuff?'"

The discussion is thus launched, and the author proceeds to get such abounding proofs of hell out of the most modern science as must raise the spirits of his desponding flock. The advance of science does not trouble him; he accepts its latest conclusions in the most liberal spirit, but finds them all subservient to his purpose. After proving immortality on scientific grounds, he goes on to establish that—

The law of affinity proves a hell.
The law of association proves it.
The law of growth proves it.
The law of propagation proves it.
The law of involution proves it.
The law of evolution proves it.

This is a pretty strong programme, but what does the Rev. W. H. Platt really mean by "hell"? One is led to suppose from the way he starts off that he means to stick to the literal, old-fashioned notion, and not yield to any amelioration of modern theology in regard to this important term. Indeed, he gives a side-thrust at Mr. Beecher by putting a passage from Beecher's San Francisco lecture into the mouth of his skeptic as follows: "'Any way,' said the skeptic, 'the old creed and religion must give way. There is just as certainly a change in the whole religious thought of the race as that the sun shines. Doctrines taught fifty years ago are neither taught now as they then were nor believed as they then were believed.'" This the preacher stoutly denies. But, when he says "antipathy of evil to good is hell," is he not making a new definition that would have been scouted by orthodox theologians half a century ago? Again, he says, "'Suffering makes all places hell—just as mental suffering is greater than bodily suffering so its hell is worse,' said the preacher. 'We have been taught that hell is a locality, and so it is. The shadow and the beam each have its place. But as a village is nothing to an empire, to a continent, to a hemisphere; as the center is nothing to a circumference; as a point is nothing to all space, so is the placed hell of past teachings as nothing to the unplaced hell of science. To the evil 'all places are hell.' Hell is in the presence of broken law, whether in mind or matter, in time or eternity.'"

A quarter of a century ago this would have passed for flat Universalism.

The Reign of God not the Reign of "Law." By Thomas Scott Bacon. Baltimore: Turnbull Brothers. Pp. 400. Price, $1.50.

A prosy, unreadable book by a very devout but foolish man, who is in a state of anxious alarm at the progress of science, and proposes to resist it by clinging with increasing desperation to the most literal orthodox interpretation of Scripture. We do not by any means intimate that the author is a fool; on the contrary, he is what is called "learned"; that is, he quotes strange lingos all through his text, and has, no doubt, been through college. He can not be strictly said to be ignorant of nature, but he is in a far worse state of mind than that of simple ignorance. There would be some hope of teaching a Digger Indian many elementary truths concerning natural things, because he has no fatal prepossessions respecting them; but this enlightened Christain has got his head so filled with the details of a great theological system, and is so palsied with fear lest it should be disturbed, that no real knowledge of nature can get entrance or hospitable reception in his mind. For example, in his chapter on our present geology and astronomy, he insists that "we may yet find that God chose to do all that work of creation in twenty-four, or in one hundred and sixty hours of our present time, which *it is absurd* to doubt that he could do." Of what use are proofs to an intellect in such a condition as this? When many years ago the fossil shells of marine life were found on the tops of high mountains, and the question arose how they came there, the monks readily replied that they were created at first in their fossil forms with the divine intention of testing men's faith in the power of God to do things exactly as he pleased. This is now regarded as sufficiently absurd, and is often quoted to illustrate the stupidity of the monks; but their frame of mind survives in our author. In a foot-note he says: "Indeed, it is far more rational to think that the eternal Lord made in a moment of time all this nature, and with its suggestiveness to the merely worldly mind of long processes of creation, meaning this as one of those mysteries of spiritual discipline which we find everywhere else, and which are greater than all matter, thus trying and training our

faith in him." What a notion of the Deity!

Health Primers: No. 1, Exercise and Training; No. 2, Alcohol, its Use and Abuse; No. 3, The House and its Surroundings; No. 4, Premature Death, its Promotion or Prevention; No. 5, Personal Appearance in Health and Disease; No. 6, Baths and Bathing. New York: D. Appleton & Co. 1879. Pp. 96 each. Price, 40 cents.

The deep and widespread interest that has of late years been taken in matters pertaining to the preservation of health has caused the publication, among much that is good, of a great deal that is bad on the subject of hygiene. This has usually appeared in the shape of crude and untrustworthy compilations, that when made the basis of practice have been productive of positive injury, and have led to a general distrust of all hygienic teaching. These Primers originated in a desire to change this state of things by supplying, in a form suited to the wants of the general reader, trustworthy information capable of practical use on the more important every-day questions relating to personal and family hygiene. Their preparation has been undertaken by several eminent medical and scientific men in London; the choice of topics and critical supervision of the work being intrusted to an able and responsible committee.

The series, when complete, will consist of fifteen volumes; six of these have now been published, and, as will be seen from the titles given above, they are all on subjects of the first importance. The writer in every case has been selected for his special acquaintance with the subject he was to treat, and as a consequence each Primer is filled with substantial and useful information, presented in a simple and elementary form, that brings it within the reach of the average reader.

Some idea of the valuable practical information contained in these volumes may be gained from the following *résumé* of the contents of those already published:

No. 1, on "Exercise and Training," is illustrated, and deals first with the "General Principles" of the subject; this is followed by "The Exercise suitable for Different Ages, Sex, and Physical Conditions"; and the Primer closes with a chapter on "Training," in which the relations of different dietaries to exercise, the amount of exercise required, its due regulation, etc., are considered. In No. 2, on "Alcohol," the properties of this substance are first described in an "Introduction"; then come, the forms in which it is used as a beverage; its effects when taken sparingly and in excess; the diseases it gives rise to; and its right use, if used at all. No. 3, on "The House and its Surroundings," opens with a chapter pointing out the common defects observed in houses; treats next of site and construction; then of drainage; water-supply; closets and plumbing; warming and lighting; bedrooms, kitchen, etc.; and the operations of purification. No. 4, on "Premature Death," begins with a statement of the proportion of people who die before their time; this is followed by a description of the principal causes of premature death; and, lastly, we are told what to do to secure a reasonable length of days. In No. 5, on "Personal Appearance in Health and Disease," the form and size of the body, with their healthy variations, are first described; the changes that take place in the fatty layer or tissue are next discussed; then the changes observed in the bony framework; the changes in the organs due to development, etc.; artificial alterations of shape; color and changes of color; and, lastly, temperament and habit. No. 6 treats of the "Physiological Action of Baths"; varieties of baths; bathing localities; and the uses of the bath.

Draper's Scientific Memoirs. New York: Harper & Brothers. 1878.

We briefly noticed this interesting work some months ago, with the intention of recurring to it again at a favorable opportunity, to enforce some points not then considered. Meantime there has appeared a review of the volume in the "London, Edinburgh, and Dublin Philosophical Magazine," that is both so authoritative and so pertinent that we can not do better than transfer it to the columns of "The Popular Science Monthly." Dr. Draper contributed numerous articles descriptive of his important researches to the pages of that magazine at the time his investigations were made. Many of the

results which he reached were at once accepted as valid advances in the fields of Physics, Chemistry, and Physiology. But, in regard to the study of the radiations and the new results attained in that field, matters took a different turn. There was a long series of quiet preliminary inquiries that paved the way for the splendid demonstrations of spectrum analysis, but which were unappreciated and thrown into the shade after that brilliant discovery. A new epoch seemed to be suddenly created, and men cared little to know who had gone before and prepared for it. Unfortunately, this condition of things was favorable to the misappropriation of results gained by pioneer laborers. As the conductors of the "Philosophical Magazine" were of course aware of what had appeared in their pages, and were familiar with the early history of this train of researches, we had not much doubt that they would speak to the point when the time came. Our readers will observe that in the subjoined notice of Dr. Draper's work they have done so, thus decisively confirming the positions that we have formerly taken in regard to the priority of Dr. Draper in the investigations that led up to spectrum analysis.

Dr. Draper here brings together the scattered memoirs and essays that he has written during the past forty years on subjects connected with radiation and radiant energy. They are thirty in number, and, for the most part, are simply reprints; but in a few cases the original memoirs are condensed, and in one or two cases the article here given is the substance of a considerable number of detached articles. Most of them have already appeared in our pages; the earliest of them, on subjects relating to photography, appeared in 1840. "I have endeavored," the author tells us, "to reproduce these memoirs as they were originally published. When considerations of conciseness have obliged me to be contented with an abstract, it has always been so stated, and the place where the original may be found has been given. Sometimes, the circumstances seeming to call for it, additional matter has been introduced; but this has always been formally indicated under the title of 'Notes,' or included in parentheses" (p. x.).

It is probably known to our readers that Count Rumford made a donation to the American Academy of Arts and Science (similar to that which he made to the Royal Society) for rewarding discoveries and improvements relating to light and heat made in America. The Academy has been rather chary of bestowing its honors, and had only awarded its Rumford Medal four times before it made the award in 1875 to Dr. J. W. Draper "for his researches in radiant energy." This circumstance has determined the selection of articles in the present volume. It comprises the researches on which the award was founded.

The President's statement of the grounds of the award is given in the Appendix, and may be summarized as follows:

(*a.*) Independent discovery of Moser's images.

(*b.*) Measurement of the intensity of chemical action of light, by exposing to the source of light a mixture of equal volumes of chlorine and hydrogen.

(*c.*) Application of Daguerreotype process to taking portraits.

(*d.*) Application of ruled glasses and specula to produce spectra for the study of the chemical action of light.

(*e.*) Investigation of the nature of the rays absorbed by growing plants in sunlight.

(*f.*) Discussion of the chemical action of light, and proof that rays of all wave-lengths are capable of producing chemical changes.

(*g.*) Researches on the distribution of heat in the spectrum.

And, finally, an elaborate investigation, published in 1847, by which he established the following facts, which we will give in the words of the award:

1. All solid substances, and probably liquids, become incandescent at the same temperature.

2. The thermometric point at which substances become red-hot is about 977° Fahr.

3. The spectrum of an incandescent solid is continuous; it contains neither bright nor dark fixed lines.

4. From common temperatures, nearly up to 977° Fahr., the rays emitted by a solid are invisible. At that temperature they are red; and the heat of the incandescing body being made continuously to increase, other rays are added, increasing in refrangibility as the temperature rises.

5. While the addition of rays, so much the more refrangible as the temperature is higher,

is taking place, there is an increase in the intensity of those already existing. The award then proceeds as follows: Thirteen years afterward Kirchhoff published his celebrated memoir on the relations between the coefficients of emission and absorption of bodies for light and heat, in which he established mathematically the same facts, and announced them as new.

We are, of course, aware that this is rather a burning question; but, whatever may be thought of the justice of these claims, there can be no doubt that the fact of their having been made on behalf of Dr. Draper by so distinguished a body as the American Academy of Arts and Science ought to be known, and that its judgment will receive at least respectful consideration whenever the early history of spectroscopic science comes to be written. And it is impossible not to draw attention to this fact in a notice, however brief, of Dr. Draper's volume; for, plainly, one of the motives of its publication is to assert his claims to priority of discovery in regard to the points above quoted. In fact, the four memoirs which bear directly on the subject of spectrum analysis are printed first in the volume, and are followed by a note in which Dr. Draper complains, though in very decorous language, that he has received considerably less than justice at the hands of M. Kirchhoff; and, by way of showing that he has tangible grounds for complaint, he makes the following quotations (p. 85) from M. Jamin's "Cours de Physique," in which results that he had previously established are formally attributed to M. Kirchhoff:

> M. Kirchhoff has deduced the following important consequences:
>
> Black bodies begin to emit at 977° Fahr. red radiations, to which are added successively and continuously other rays of increasing refrangibility as the temperature rises.
>
> All substances begin to be red-hot at the same temperature in the same inclosure.
>
> The spectrum of solids and liquids contains no fixed lines.*

Now, it may be said with very little qualification that what is here attributed to M. Kirchhoff is to be found distinctly stated in the first memoir in the volume before us, which was published by Dr. Draper in 1847. By experimenting with a strip of platinum heated by the transmission of a current whose force could be regulated, he ascertained that the temperature at which red rays are first radiated is 977° Fahr. He also ascertained that platinum, brass, antimony, gas-carbon, and lead became incandescent at the same time with the iron barrel in which they were gradually heated, and that the apparent exceptions presented by chalk, marble, and fluor-spar were due to phosphorescence. By raising the temperature of the platinum wire and analyzing with a prism the light emitted, he proved that the length of its spectrum gradually increased with the temperature until at 2130° Fahr. the full spectrum of daylight was attained; and it is clear that he regarded the result thus obtained as being generally true. That the spectrum of the incandescent platinum contained no dark lines had indeed come out only incidentally in the course of the investigation; still it was not by any means a point seen but not observed; for, in consequence of observing it, he resorted to a comparison of the spectra of incandescent platinum at different temperatures with the spectrum of daylight in order to determine their extent, instead of fixing their extent by the dark lines of the spectra themselves, which he had ascertained to be non-existent. On the whole, the above statement breaks down at nearly every point. What is therein referred to M. Kirchhoff was certainly ascertained before by Dr. Draper. Whether Dr. Draper was the first person to observe all these points is a very different question, and one we would by no means prejudge; indeed, without going beyond the limits of the first Memoir, it is pretty plain that the temperature of incandescence was known with considerable accuracy before Dr. Draper's experiment with the platinum wire; and it certainly was believed (if not proved) that the temperature was the same for all bodies.

HABIT AND INTELLIGENCE. A Series of Essays on the Laws of Life and Mind. By JOSEPH JOHN MURPHY. New York: Macmillan & Co. Pp. 583. Price, $5.

THE first edition of this work appeared

* The above quotation is, we presume, to be found on pp. 463, 464, vol. iii., edition of 1866. If so, it is not exactly a quotation, but is made up of parts of a much larger statement. We may also observe that Memoir I. of the present volume is not in all respects an exact verbal reprint of this Memoir published in our "Journal" for May, 1847. This does not, however, affect the point at issue.

nearly ten years ago. It was favorably received, and the author has been encouraged to pursue still further the line of thought there opened. This second edition is so nearly rewritten as to be practically a new work. Several chapters have been removed, and others condensed and modified, while much new matter has been added. It is obvious that there are two chief elements in this change: first, the progress of the subjects, or the increase of our actual knowledge concerning them; and, second, the author's own progress in mastering them. He is occupied by the most tangled and obscure of modern investigations, upon many of which the intellect of the world has but just fairly entered; these he discusses from an independent point of view, putting forth his own conclusions freely and fully. These are such as to merit attention; and the reader who desires to be thoroughly up in modern biological and psychological discussion will find much in Mr. Murphy's volume to repay attention.

The National Dispensatory: Containing the Natural History, Chemistry, Pharmacy, Actions, and Uses of Medicines, including those recognized in the Pharmacopœias of the United States and Great Britain. By Alfred Stillé, M. D., LL. D., Professor of the Theory and Practice of Medicine and of Clinical Medicine in the University of Pennsylvania, etc., and John M. Maisch, Ph. D., Professor of Materia Medica and Botany in the Philadelphia College of Pharmacy, Secretary to the American Pharmaceutical Association. In one very handsome octavo volume of over sixteen hundred closely-printed pages, with over Two Hundred Illustrations. Extra cloth, $6.75; leather, raised bands, $7.50. Philadelphia: Henry C. Lea.

The range of the sciences connected with materia medica and therapeutics is not only a very wide but also an ever-shifting one, growing by constant accessions of facts and material, condensing by sifting and discarding, and appropriating all that which has proved of real and more than ephemeral value. Pharmacopœias and compendiums of materia medica, in order to keep pace with both accessions and restrictions, and with general progress, have therefore to be revised or rewritten from time to time.

In the United States, where there as yet is no legally authorized Pharmacopœia, and the existing one is but the voluntary work of delegates from a number of medical and pharmaceutical societies and colleges, the "United States Dispensatory," of Professors Wood and Bache, for more than forty years has been the unrivaled standard in this special and important branch of the healing art, and as such has, to a very large extent, overshadowed the "Pharmacopœia." Since the appearance of the fifth decennial revision of the "United States Pharmacopœia" in 1873, and the failure of the "United States Dispensatory" to embrace in time its improvements, alterations, and additions in the way of a new commensurate edition, the want became more and more patent of a new critical digest, supplementing the Pharmacopœia, representing the advanced state of materia medica, and discarding the bulk of obsolete material. The announcement some years ago that Professors Stillé and Maisch, of Philadelphia, had engaged in the preparation of such a work was therefore received with the more satisfaction and confidence, as both authors are recognized authorities in their respective departments. The result of their joint labor has now made its appearance in the above-named volume, containing 1,540 pages, 88 pages of indexes, and 201 illustrations.

The practical importance of the objects of this work, the elaborate and comprehensive treatment of the immense material, embracing the natural history, chemistry, pharmacy, and the actions and uses, of the entire domain of the present materia medica, in a concise and lucid style, and commensurate with the advanced state of the kindred sciences, make the "National Dispensatory" at once a complete digest of its kind in the English language and a creditable publication of the American press.

Without entering in detail upon a critical survey of this voluminous work, of its many excellencies and comparatively slight and few shortcomings, it affords us special pleasure, in justice to its intrinsic value, its importance, and its prospective usefulness, to add our unqualified approval of the masterly way in which the authors have accomplished their task, and have succeeded in furnishing for general use, and to the professions of pharmacy and medicine in par-

ticular, a complete and trustworthy guide both for ready reference and for study. In this connection we hope that it may prove an effectual impetus to, and become largely instrumental in, the better, more correct, and more thorough study of pharmacology so much needed by pharmacists, druggists, and physicians, and at the pharmaceutical and medical schools of our country.

The publisher deserves due credit for the good style in which the book has been brought out. If shortcomings in this respect can be pointed out, they consist mainly in the comparative inferiority of quite a number of the woodcuts. While a few of them—as, for instance, on pages 314, 645, 866, and 1161—are equal to the excellent illustrations of the corresponding standard works of the French, and in particular of the German literature, others are less satisfactory, and in not a few cases inadequate to such an elaborate work and to the present state of xylography. Future editions can remedy this want, and in this respect enhance the value of the work by a liberal addition of pharmacognostical illustrations.

PUBLICATIONS RECEIVED.

Fasting Girls: Their Physiology and Pathology. By Wm. A. Hammond, M. D. New York: Putnams. 1879. Pp. 76. 75 cents.

Fashions of the Day in Medicine and Science. By H. S. Constable. Kingston-upon-Hull: Levy & Co. 1879. Pp. 300.

Sewer Gases. By A. de Varona. With Plates. Brooklyn: "Eagle" print. 1879. Pp. 157. 75 cents.

Mixed Essays. By Matthew Arnold. New York: Macmillan & Co. 1879. Pp. 347. $2.

Life and Letters of Frances Baroness Bunsen. By A. J. C. Hare. Two vols. in one. With Portraits. New York: Routledge & Sons. 1879. Pp. 516 and 486. $5.

The Teacher. Hints on School Management. By J. R. Blakiston. New York: Macmillan & Co. 1879. Pp. 106.

The Color-Sense. By G. Allen. Boston: Houghton, Osgood & Co. 1879. Pp. 294. $3.50.

Aids to Family Government. By B. Meyer. New York: Holbrook. 1879. Pp. 208. $1.

A Voyage with Death, and other Poems. By A. Welcker. Oakland, Cal.: Strickland & Co. Pp. 78.

Report of the New York City Board of Education. 1878. Pp. 419.

The Grocer's Manual. By P. H. Felker. Claremont, N. H.: Claremont Manufacturing Co. 1878. Pp. 312.

Chesapeake Zoölogical Laboratory. Session of 1878. With Plates. Baltimore: Murphy print. 1879. Pp. 170.

Native Flowers and Ferns of the United States. By Thomas Meehan. Parts 21, 22, 23, 24. Boston: Prang & Co. 50 cents each.

Report of the Ontario Institution for the Blind (1878). Toronto: Robinson print. Pp. 29.

American Chemical Journal. Edited by Ira Remsen. Vol. I., No. 1. Baltimore: Innes & Co. print. Pp. 76. $3 per volume, 50 cents per number.

Journal of Physiology. Supplement to Vol. I. London and New York: Macmillan. Pp. 62.

Nests and Eggs of American Birds. By E. Ingersoll. Part I. With Plates. Salem, Mass.: Cassino. Pp. 20. 50 cents.

Report of the Western Pennsylvania Institution for the Deaf and Dumb (1878). Pittsburg: Stevenson, Foster & Co. print. Pp. 55.

The Silkworm. Washington: Government Printing-Office. 1879. Pp. 31.

D'Unger's Cure for Dipsomania. Chicago: The Author. Pp. 16.

Organon of Science. By J. H. Stinson. Eureka, Cal.: Ayres print. Pp. 193.

Statistics of the Treasury Department (September, 1878). Washington: Government Printing-Office. Pp. 117.

Economic Monographs; International Copyright; Free Trade; Hindrances to Prosperity; Honest Money and Labor; National Banking. New York: Putnams. 1879. 25 cents each.

Report of the Eastern Penitentiary of Pennsylvania. Philadelphia: McLaughlin Brothers print. 1878. Pp. 130.

Journal of the Academy of Natural Sciences of Philadelphia. Vol. III., Part II. With Plate. Philadelphia: The Academy. 1876. Pp. 114.

Observations of the Solar Eclipse of July 29, 1878. By L. Waldo. With Plates. Cambridge: Press of J. Wilson & Son. 1879. Pp. 60.

Improved Dwellings for the Laboring Classes. With Plates. New York: Putnams. Pp. 45. 30 cents.

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POPULAR MISCELLANY.

Famines in Ancient and Modern Times.—In a statistical paper recently published, Mr. Cornelius Walford gives a chronological table of the famines of which historic record exists, and then in twelve other tables notes the operation of the various causes, natural and artificial, which tend to produce famines, among the natural causes being floods and inundations, frost, drought, sundry other meteorological phenomena, insects, and vermin. The artificial causes are considered under the heads of war, defective agriculture, defective transport, legislative interference, currency restrictions, speculation, and, finally, misapplication of grain. What strikes the reader who glances at the first table is the great frequency of famines in earlier times, as compared with the present. Take, for instance, the record of two or three hundred years, beginning with the year 600, and compare it with that of the hundred years beginning with the year 1775. And, in making this comparison, it must be remembered that such events are sure to find permanent record to-day, while in earlier times the record was local, and has in many instances since been effaced. Mr. Walford's first table records, under the date 600 to 604, famine in France; 605, in England; 625, in Britain (*grievous*); 664, Ireland—great famine; 667, Scotland (grievous); 669, France—great famine; 669, Ireland—great scarcity, also in the following year; 680, Britain, from three years' drought; 695, England, and 700, Ireland—famine and pestilence for three years, "so that men ate each other"; 703, Italy—three years' famine; 712, Wales; 730, England, Wales, and Scotland—great famine; 748, Scotland; 759, Ireland—great famine; 768, same country—famine, and again 772; 774, Scotland—famine, "with plague"; 791, Wales—grievous famine; 793, England—famine; 803, Scotland—"terrible" famine; 822–'23, England—"thousands starve"; 824–'25, Ireland—great dearth; 836, Wales—"the ground covered with dead bodies of men and beasts"; 845, Bulgaria—great famine; 851, Italy and Germany—famine; 856, Scotland—a four years' famine began; 836, same country—famine, with plague; 872, England—famine "from ugly locust." In this century Paris was visited by famine three times. Now, turn to the record of the last hundred years. In 1775, at Cape de Verde—great famine—16,000 persons perish; 1789, France—grievous famine, province of Rouen; 1795, England—scarcity of food severely felt; 1801, United Kingdom—great scarcity; flour obtained from America; 1812, England and Ireland—great scarcity; 1813, Poland—famine consequent on an inundation; same year 5,000 souls perished in Sweden; 1822, Ireland—dreadful famine, produced by failure of potato crop; 1832, same country—famine—Parliament grants £40,000 for relief, and £74,410 subscribed in England; 1845, same country—Parliament advanced £10,000,000—275,000 persons supposed to have perished; famine lasted nearly six years; 1,029,552 persons died in this period from starvation and pestilence consequent on it; population reduced by these causes and emigration by about 2,500,000; 1847, France—scarcity; 1877, Brazil—upward of 200,000 of the population exposed to famine. We have purposely omitted notices of the famines in countries outside of Europe, or not settled mainly by Europeans. In such regions famine is at least as frequent and dread a visitant as ever it was. The contrast made by the foregoing figures is highly creditable to modern civilization.

The Age of the World.—The age of the world, as estimated by T. Mellard Reade, in a paper contributed to the London Royal Society, is enormously in excess of the limits assigned by certain physicists, and allows ample time for the production of all the changes of the organic and inorganic world postulated by the theory of evolution. Limestones, he remarks, have been in course of formation from the earliest known geological periods, but it would appear that the later-formed strata are more calcareous than the earlier, and that there has in fact been a gradually progressive increase of calcareous matter. The very extensive deposition of carbonate of lime over wide areas of the ocean-bottom at the present day is attested by the soundings of the Challenger. According to Mr. Reade, the sedimentary crust of the earth is at least one

mile in average actual thickness, of which probably one tenth consists of calcareous matter. In seeking the origin of this calcareous matter, it is assumed that the primitive rocks of the original crust were of the nature of granitic or basaltic rocks. By disintegration of such rocks, calcareous and other sedimentary deposits have been formed. The amount of lime-salts in waters which drain districts made up of granites and basalts is on an average about 3·75 parts in 100,000 parts of water. It is further assumed that the exposed areas of igneous rocks, taking an average throughout all geological time, will bear to the exposures of sedimentary rocks a ratio of about one to nine. From these and other data Mr. Reade concludes that the elimination of the sedimentary strata must have occupied at least six hundred million years. This would be the minimum age of the world. The author infers that the formation of the Laurentian, Cambrian, and Silurian strata must have occupied about two hundred million years; the Old Red Sandstone, the Carboniferous, and the Poikilitic systems another two hundred million; and all the other strata the remaining two hundred million.

Professor Clarke on Lockyer's Researches.—Professor F. W. Clarke, of Cincinnati, sends a letter to "Science News" in relation to the recent views of Mr. Lockyer on the compound nature of the chemical elements. Professor Clarke was himself early in that field, and published a very suggestive article in "The Popular Science Monthly" of January, 1873, on "Evolution and the Spectroscope," in which he announced on spectroscopic grounds the hypothesis that the evolution of planets from nebula had been accompanied by an evolution of complex from simple forms of matter. The idea was based upon the gradation in chemical complexity of the celestial spectra. About eight months later Mr. Lockyer put forth essentially the same views, resting them upon exactly the same evidence. Professor Clarke then goes over the ground recently taken by Lockyer, and recognizes that he has decidedly advanced the inquiry from a theoretical point of view. He traces the new lines of evidence, and considers that absolute demonstration may perhaps be attainable only by an actual decomposition of the elements in the laboratory; but a probability so strong as to command universal acceptance may be otherwise established. Mr. Lockyer has done much toward establishing this probability, and it is to be hoped that he will successfully continue his labors in the same direction. Meanwhile, chemists must seek new evidence from other sources, until, one way or another, the vexed question shall be laid definitely at rest.

The Distinctions between Man and Animals.—In a brief and sprightly, if not very profound article, a writer in the "Monthly Journal of Science" examines the validity of one of the principal distinctions which have been drawn between man and animals, namely, the supposed fact that while men progress as individuals, as communities, and as a species, animals stand stock-still, each succeeding generation attaining just the development of its predecessor and nothing more. The author, on the contrary, maintains that the individual man does not make progress from the cradle to the grave, but that, from the middle of life, and often indeed from an earlier date, he is a mere bundle of habits and prejudices: no further mental growth is possible, however long he may happen to survive. To a man, then, brutes exhibit no well-marked contrast, but a decided similarity: in the earlier part of life they are, like ourselves, capable of progress; but later their faculties are blunted, and, like man, they become stationary; as far, therefore, as individual progress is concerned, man and beast differ only in degree. There is also among mankind a national or tribal progress distinct from that of the individual and that of the species, but, like them, not unlimited in extent and duration. Nations decay, and the cause of this decay is to be sought in the decline of that which in a nation corresponds to vitality in the individual—the "tribal instinct." Among those animal species which live in organized communities or nations the very same phenomenon occurs, and every ant-hill might have its Gibbon. The author here cites the observations of Berthelot, already quoted in the "Monthly" (current volume, p. 248.) It remains to consider the real or fancied superiority of every generation of mankind

over the foregoing; this superiority the author calls in question. Even as regards knowledge and power, the advance which some claim as a characteristic of humanity is effected by exceptional individuals who arise in certain races under favorable circumstances only, and is quite compatible with long intervals of immobility and even of decline. Besides, it is not proved that the lower animals are literally incapable of progress. To enforce this point the author quotes certain interesting observations made by the writer of a work entitled "Flowers and their Unbidden Guests," who had for months been in the habit of sprinkling powdered sugar on the sill of his window, for a train of ants which passed in constant procession from the garden to the window. "One day he took it into his head to put the powdered sugar into a vessel, which he fastened with a string to the transom of the window, and, in order that his long-petted insects might have information of the supply suspended above, a number of the same set of ants were placed with the sugar in the vessel. These busy creatures forthwith seized on the particles of sugar, and, soon discovering the only way open to them, viz., up the string, over the transom, and down the window-frame, rejoined their fellows on the sill, whence they could resume the old route down the wall into the garden. Before long the route over the new track from the sill to the sugar by the window-frame, transom, and string, was completely established, and so passed a day or two without anything new. Then one morning it was noticed that the ants were stopping at their old place, the window-sill, and again getting sugar there. Not a single individual any longer traversed the path that led thence to the sugar above. This was not because the store above had been exhausted, but because some dozen little fellows were working away vigorously and incessantly up aloft in the vessel, dragging the sugar-crumbs to its edge, and throwing them down to their comrades on the sill."

The Earthquake of November 18, 1878.—Of the earthquake of November 18, 1878, Professor Nipher, of the University of St. Louis, says that it was felt over an area of fully 150,000 square miles, the region disturbed forming an ellipse, with its major axis reaching from Leavenworth to Tuscaloosa, a distance of over 600 miles. The minor axis extended from near Clarksville, Arkansas, to a point midway between Cairo and St. Louis, a distance of 300 miles. The region of greatest disturbance was along the Mississippi from Cairo to Memphis. Here the shocks were universally felt; the walls of buildings could be seen to move, and strong frame houses creaked as when every joint is strained by a strong wind. At Ironton, Missouri, the shock was so severe as to alarm some of the occupants of brick houses. Along the Missouri from Glasgow to Lexington the shock was also severe, awakening many families, who thought a heavy wind-storm was in progress. The shock appears to have been felt first at Glasgow at 11 h. 23 m. (St. Louis time). The shock traveled rapidly along the axis of the ellipse, reaching Cairo at 11 h. 48 m., and Memphis at 11 h. 50 m. At Little Rock it was distinctly felt, although not observed at Clarksville, which is thirty miles farther up the river.

Physiological Effects of Arsenic.—The physiological effects of arsenic have lately been studied anew by Gies, who administered minute doses of the poison daily for four months to pigs, rabbits, and fowls. The daily dose for a rabbit was 0·0005 to 0·0007 of a gramme, for a pig 0·005 to 0·05, and for a fowl 0·001 to 0·008. In all these animals the weight of the body increased, and the subcutaneous fat was augmented. In young growing animals the bones developed considerably, both in length and in girth, and they presented the peculiarity that, wherever in the normal state spongy tissue exists, it was superseded by compact bone. Moreover, just as Weigner found to be the case in animals supplied with small doses of phosphorus in their food, a compact layer of bone was found immediately beneath the epiphyseal cartilages of the long bones. This effect was apparent after the arsenic had been given for nineteen days, and where only 0·02 to 0·035 gramme had been taken. It was observed that animals fed in the same stable presented the same appearances in the bones, which Gies refers to the air being laden with the arsenic elimi-

nated by the lungs and skin of the animals under experiment, for he found that the same changes were observable in animals kept in a cage, the bottom of which was strewed with arsenic. Besides the changes in the bones, the heart, liver, kidneys, and even the spleen, underwent fatty degeneration. The young of animals fed with arsenic were invariably born dead, though they attained a large size, and presented remarkable hypertrophy of the spleen, and incipient changes in the bones.

What shall we eat?—Dr. E. C. Angell, author of a paper in "The Sanitarian" entitled "Alimentation in Health and Disease," would make wheaten food and not beef the basis of alimentation. In a natural and rational system of dietetics wheat and the allied seed-foods, including beans, lentils, peas, and rice, must, he holds, take the place now usurped by animal foods, including, besides flesh-meats, butter, cheese, eggs, and milk. Next should come the appetizing, juicy fruits, and then the plant-foods, which are neither seeds nor fruits, and which are generally styled vegetables. After these come the various animal foods, and last of all the stimulating spices, beverages, and other food adjuncts. According to Dr. Angell, "the true life-giving and mental, moral, and physical force-producing bread is neither more nor less than sound, ripe wheat when deprived of its thin outer silicious husk, coarsely ground and mixed with water, and subjected to just that degree of kneading and baking which will suffice to prepare it for mastication, insalivation, and the subsequent action of the gastric juice." The dough should be kneaded into rolls a little larger than the largest macaroni, and when baked the product gets the name of "sticks." In these "sticks" we have every nutritious element of the grain, with no fermentation, no cryptogamic vegetation, no deleterious chemical or mineral ingredients. We have, furthermore, a substance that must be chewed, as it can not be swallowed without due mastication and insalivation, and consequently its digestion is insured. Attrition, or cold-blast wheat, coarsely ground and unbolted, contains all the natural nutritive elements of the wheat. Besides this, it possesses the mechanical properties which distend the intestines, promoting their peristaltic action; it is therefore antidotal to dyspepsia. For children it is specially valuable, and its substitution for common bread, and the use of fruits instead of flesh-food, until the deciduous teeth shall have given place to the permanent denture, would be of incalculable benefit and would contribute to the production of good teeth. "The early loss of these organs," says Dr. Angell, "is conclusive evidence that the prevailing system of dietetics is radically wrong."

Government Aid to Artisan Schools.—In England government aid is given toward the support of science schools for artisans and mechanics, a sum of money being granted to the teacher according to the number of students whom he succeeds in getting through the government examination. Furthermore, in order to encourage the students, valuable prizes are presented to those who obtain first-class certificates at the examinations, which, it may be added, are not *competitive*, that is to say, if every student succeeds in obtaining the requisite percentage of marks, all obtain what are termed Queen's prizes. If the class be one in which scientific apparatus is required, the Government pays half the cost of such apparatus. Already above 50,000 young men attain a respectable proficiency in one or more branches of practical science every year. In "Chambers's Journal," from which the foregoing particulars are taken, we find the following interesting account of the rise and progress of one of these science schools for young artisans: "In the town in which this school is situated, a few spirited young men determined to have a class during the winter. Their scheme at first met with some opposition, but the young men were bent on extending to their town the advantages which the Government of the country hold forth to the industrial classes to educate themselves; and, ere the first days of winter had gone, the class became an accomplished fact. The difficulty experienced in obtaining the requisite instruments for the class was got over partly by means of the aid from Government, and partly by the ingenuity of the young men

themselves, who constructed several of the more expensive pieces of apparatus. A great deal can be done in this way. At the very lowest computation, one half of the apparatus might be extemporized by the teacher, and, if (as was done in the town under consideration) the construction of every article were carefully explained to the students, it would give them a grasp and familiarity with the subject which they could not otherwise obtain. The subject being entirely new to every one of the students, their attention was kept up, and their interest in the work never allowed to flag, by an unsparing use of the apparatus in performing as many experiments as possible. It turned out, however, that those students who were likely to fail at the government examination would do so not because their information was defective, but because of their inability to put their thoughts into writing. From want of practice they experience so much difficulty in arranging their facts in intelligible sentences, that one half of their available time has passed before they have completed the answer to the first question on the examination paper. This difficulty was got over by giving the students questions to work at home, and having a written examination every month during the course of the session. The result proved the efficacy of this arrangement. Nearly sixty students have been examined in the first stage of the subject, and there has not been a single failure."

Japanese Archæology.—In a report of a lecture by Professor E. S. Morse, published in the "Tokio Times," we find the following list of human bones found in the kitchen-midden at Omori, their presence, together with other circumstances, indicating, in the opinion of the Professor, that the locality was once inhabited by cannibals (see "Popular Science Monthly," vol. xiv., p. 257): Right humerus; length of fragment, 195 millimetres; proximal end gone. Left humerus; length of fragment, 215 mm.; both ends gone. Left humerus; length of fragment, 160 mm.; both ends gone. Right ulna; length of fragment, 200 mm.; distal end gone. Right ulna; length of fragment, 180 mm.; both ends gone. Right radius; length of fragment, 80 mm.; upper portion only. Right femur; length of fragment, 150 mm.; proximal end and portion of shaft only. Right femur; length of fragment, 270 mm.; both ends gone. Right femur; length of fragment, 280 mm.; both ends gone. Right femur; length of fragment, 107 mm.; upper portion of shaft. Right femur; length of fragment, 304 mm.; articular surfaces broken; child. Left femur; length of fragment, 160 mm.; shaft only. Left femur; length of fragment, 270 mm.; great trochanter and head and distal end gone; child. Left femur; length of fragment, 85 mm.; lower portion only; articular surface gone; child. Right tibia; length of fragment, 135 mm.; upper portion of shaft. Right fibula; length of fragment, 205 mm.; both ends broken. Fifth right metatarsal; length, 65 mm.; distal articular surface partially gone. Left lower maxillary. Left parietal.

How the Humming-Bird feeds.—Mr. A. R. Wallace's account of the way in which the humming-bird takes its food, whether nectar or insects, would appear to be erroneous in the light of the observations made by W. H. Ballou, of Evanston, Illinois. According to Wallace, "the tubular and retractile tongue enables the bird to suck up honey from the nectaries of flowers, and also to capture small insects; but whether the latter pass down the tubes, or are entangled in the fibrous tips and thus drawn back into the gullet, is not known." Mr. Ballou's observations are recorded in the "American Naturalist." He attracted to his house two humming-birds by a saucer of sirup placed on the window-sill, to which the birds would come every day to satisfy their hunger. They always alighted on the edge of the saucer, and *lapped the sirup* as a dog laps water. The question whether insects "pass down the tubes or are entangled in the fibrous tips and are thus drawn back into the gullet" was also solved by Mr. Ballou. Insects too large to pass through these tubes being placed in their way, the birds were observed to take them as readily as smaller ones. The insects were evidently secured by adhesion to the saliva of the tongue-tips, and thence drawn into the gullet. The author

thinks that the tubes of the tongue connect with the lungs rather than with the digestive passage. These interesting observations were abruptly terminated one day by the coming of a third "hummer"—a male —who drove the others from the window, and, in a fit of rage, darted at one of them, and thrust his bill well through its body; both then fell to the ground dead.

Wines as Intoxicants.—Supposing two wines, a white wine and a red, to contain the same proportion of alcohol, may the one be more intoxicating than the other? That such is the case appears from a communication to the London "Spectator" by Samuel James Capper, who declares it to be an incontestable fact that in all white-wine districts, and of course in all cider-producing countries, drunkenness is much more prevalent than where red wine is grown. Mr. Capper quotes the observations of a lady who was in the habit of spending six months of the year in a château on the Loire, while the other six months were spent on an estate near Dinan. "She assured me," writes Mr. Capper, "that the difference in the matter of sobriety was most marked between the peasants on the Loire, whose habitual beverage was red wine, and the Normans and Bretons, who drink cider, to the exclusion of everything else, even water." He adds that "in the Pays de Vaud the abundant supply of white wine is admitted by all thoughtful inhabitants to be a great curse. Very few laboring men attain old age, their nervous systems breaking down entirely, through their intemperate use of the product of the smiling vineyards that line the shores of Lake Leman. An hotel proprietor of great experience assured me that he found it better in every way to supply his servants and laborers with a cheap red wine from France than to let them drink the white wine of the country." Mr. Capper accounts for the difference in the effects of red and white wine by the fact that the former is very rich in tannin, which is absent in the latter. The tannin exercises an astringent influence, and closes the pores of the stomach, thus preventing the alcohol from going straight to the brain, as it does in the case of white wine.

Grief in a Chimpanzee.—That the chimpanzee is capable of feeling grief, regret for the death of a companion, Mr. A. E. Brown holds to be proved by the behavior of the surviving one of a pair of those animals kept for some time in the Zoölogical Garden of Philadelphia. The animals had been very much attached to each other; they never quarreled, and, if occasion required one to be handled with any degree of force, the other was always prepared to take its part. After the death of the female, her consort made many attempts to rouse her, and when this was found to be impossible his rage and grief were piteous. Tearing the hair, or rather snatching at the short hair on his head, had always been one of his common expressions of extreme anger, and he was now seen to do this frequently; but the ordinary yell of rage which he set up at first finally changed to a cry before unheard by the keeper, and which may be represented by *hah—ah—ah—ah—ah*, uttered somewhat under the breath, and with a plaintive sound like a moan. He made repeated efforts to awaken his dead companion, lifting up her head and hands, pushing her violently, and rolling her over. After the body had been removed from the cage he became more quiet, and remained so as long as his keeper was with him, but, catching sight of the body once when the door was opened, and again when it was carried past the front of the cage, he became violent, and cried for the rest of the day. The day following he sat still most of the time and moaned continually; but this gradually passed away, and from that time forward he has manifested a sense of a change in his surroundings only by a more devoted attachment to his keeper and a longer fit of anger when he leaves him.

Sensibility of the Eye to Light.—A highly interesting series of experiments on the sensibility of the eye to light is described by Charpentier, in a communication to the Paris Academy of Sciences. With the aid of a special apparatus for graduating at will the intensity of the incident rays, he finds that if the intensity be gradually increased from zero the sensation is developed after a certain minimum degree has

been reached. But, if the intensity of the stimulus be now as gradually diminished, the eye will continue to perceive it till it has fallen to one third or one fourth of the original minimum. In producing the initial sensation a certain amount of light has, so to speak, been wasted in putting the machinery in motion. Further, if the eye has been carefully shielded from the light for some minutes before performing the experiment, it will be capable of perceiving light which is fifty or even one hundred times less intense than that required to produce a luminous sensation. This enormous difference is equally manifested whether monochromatic or white light be employed. Now, if we apply a similar test to the sensation of color, we find that for the chromatic as for the luminous stimulus a certain minimum is needed to produce the sensation, which still continues to be excited when the intensity of the stimulus is progressively diminished. So far, the two sensations, of light and color, obey the same law. But if we proceed to compare the sensitiveness of the eye in full activity with that of the eye which has been allowed a period of absolute rest, we no longer find any such increase in its susceptibility to the chromatic stimulus as was observed in the case of light. This result is altogether opposed to the current opinion that the sensation excited by white light is really a resultant of the simultaneous development of several determinate color sensations; it shows, on the contrary, that the sensation of light is altogether independent of that of color, and really a simpler kind of reaction on the part of the visual apparatus.

"Oil on the Troubled Waters."—The fishermen of the Shetland Isles, as we learn from a writer in "Chambers's Journal," are wont, when in utmost peril during a storm, to throw oil on the waters to still them. They crush in their hands the livers of any ling or cod they may have caught, and keep throwing them astern and around them. "The effect," we are told, "is magical. The waves are not lessened in size; but they no longer *break*, and it is only from their breaking close to the boat and so being dashed in upon her and filling her that there is danger. The rapidity with which the oil spreads over a considerable space of sea around is marvelous, and scarcely to be credited except by one who has witnessed the phenomenon." An expedient so simple might often be of invaluable service in saving life and property. The difficulty and peril, for instance, of launching a boat from a sinking ship in a storm are mostly caused by the wind breaking the waves over the boat and filling her or dashing her against the vessel's side. "The danger of such a mishap would unquestionably be greatly lessened by throwing overboard some oil, which ought always to be kept handy. Boats also going from one ship to the assistance of another in distress, and life-boats on their way to a wreck, and boarding it, might often with very great advantage use a little oil, if its effects were only better known. Another case in which oil might be of the greatest service is when a man accidentally falls or is washed overboard. Life-buoys are thrown into the sea, the ship is brought to as quickly as possible, boats are lowered and a search made; but, before all this can be done, the vessel has run a considerable distance, and, although the poor struggler in the water may be a good swimmer and able to keep afloat for some time, the great difficulty is to find the exact spot where he is to be sought for. A life-buoy or a man's head is a small object to descry among heaving waves and white foam. If life-buoys were constructed so as to contain a small portion of oil in a little receptacle or India-rubber bag attached to them, to be punctured with a knife before being thrown overboard, the effect would be not only to prevent the sea from breaking over the castaway, so making it easier for him to keep afloat, but would indicate to the searchers almost the exact spot where to look for him."

NOTES.

The commonly received theory of dew is that it results from the condensation of the moisture of the air by contact with surfaces of a lower temperature. This theory is rejected by Professor Stockbridge, of the Massachusetts Agricultural College. He holds dew to be the vapor from the soil condensed by the cooler air, and states as follows the results of his experiments: 1. The vapor of the soil is much warmer at night than the air, and would be condensed by it. 2. Va-

por from the soil is soon diffused and equalized in the whole atmosphere, but in the largest proportion when evaporation is taking place near the surface of the soil; and, other things being equal, plants nearest the earth have the most dew. 3. Dew under haycocks, boards, and like objects on the ground, could receive it from no other source.

Professor Baird has dissipated the cloud of mystery which from olden time has veiled the mode of propagation of the eel by his finding the ripe ovaries of the animal. It appears that what Professor Baird shows to be the ovary of the eel has been known under the name of "eel-fat." This "fat," under the microscope, is seen to consist of egg-cells, of which a single fish may contain as many as 9,000,000.

At a meeting of the Baltimore Academy of Medicine, Dr. McSherry recounted the case of a lady who took cold two years ago, from sleeping in damp sheets, and has ever since been devoid of the sense of smell. Her sense of taste is also impaired to such a degree that she can not distinguish between different sorts of meats and vegetables. Pepper she recognizes by its pungency. The hearing is acute. Another physician present cited the case of a lady who lost the sense of smell several years ago, from catarrhal trouble. She is unable to distinguish the different kinds of food and drink. Her mother met with the same loss after typhoid fever, and never recovered from it. In another case the sense of smell was lost after illness, that of taste being retained.

An examination of the blood of *Cephalopoda* by Frédéricq shows that in the oxidized state corresponding to that of our arterial blood, this liquid is of an intense blue color, and that as it loses its oxygen it grows pale. It contains a substance analogous to hemoglobine, in which a metal plays the same part as iron in the blood of superior animals, but in the cephalopod the metal is copper.

A Spanish technical journal, the "Gaceta Industrial," pronounces American-made cartridges to be superior to all others, the superiority being due in part to the alloys used in the manufacture, in part to the machinery, and in part also to the skill of the workmen. Foreign governments have sent experts hither to study the methods in use in our factories, but the result has been unsatisfactory.

In 1872 the population of the city of Tokio (formerly Yedo) was 595,905 souls. It has since nearly doubled, for the last census shows it to be now 1,036,771. The number of houses is 236,961, or one house per 4·37 of the inhabitants.

A woman in England having received an injury on the leg which caused a profusely bleeding wound, applied a poultice of tobacco to the injured part. Soon the patient exhibited alarming symptoms, and a physician being called, found her extremely prostrated: there were dimness of sight, dizziness and confusion of thoughts, nausea, and vomiting. The poultice was removed, an antidote (strychnia) and stimulants administered, and the patient slowly improved.

The yearly consumption of quinine in the United States is computed at 800,000 ounces; at an average price of $2.50 per ounce, this represents an annual outlay for this drug of $2,000,000. Of opium the annual consumption, whether as a medicinal agent or as an intoxicant, is 220,000 pounds, costing, at four dollars per pound, rather less than one million dollars.

The cremation method of disposing of dead bodies is not making very rapid progress toward universal acceptance either in England or the United States. The medical press of the former country appears to be opposed to the practice. The celebrated crematory at Washington, Pennsylvania, the only one in the United States, has, we learn from the "Medical and Surgical Reporter," been converted into a factory for canning fruits!

In the present year occurs the eighteenth centenary of the destruction of Pompeii and Herculaneum by an eruption of Mount Vesuvius. It is intended to commemorate this event in a becoming manner next November, and invitations have been issued to the most eminent Italian archæologists to be present on the occasion.

The honey mesquite is one of the principal forest trees of Texas. It is a short, spreading tree, attaining an average trunk-diameter of eighteen inches. It belongs to the *Leguminosæ*, and bears pods nine to ten inches long, containing beans imbedded in a sweet pulp. Both the beans and the pulp are eaten by the Indians, and they form good fodder for horses. The wood is very hard and durable.

In the summer of 1877 some remains of an old Roman bridge—viz., a number of oak piles and beams—were found in the bed of the Neckar, at Heidelberg. Some of the piles were drawn with the iron points or shoes which had been used to drive them into the ground, and these shoes were found to be of the same shape and strength as those used at the present day for like purposes. Of the seven piers which supported the roadway of the bridge, five were found *in situ* at equal distances (thirty-four and a half metres) from each other.

W. KINGDON CLIFFORD.

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THE CONDITION OF WOMEN FROM A ZOÖLOGICAL POINT OF VIEW.

By W. K. BROOKS.

I.

ZOÖLOGY is the scientific study of the past history of animal life, for the purpose of understanding its future history. Since man has, in part at least, conscious control of his own destiny, it is of vital importance to human welfare in the future that we should learn, by this comparative study of the past, what are the lines along which progress is to be expected, and what the conditions favorable to this progress, in order that we may use our exceptional powers in harmony with the order of nature.

The study of the growth of civilization shows that human advancement has been accompanied by a slow but constant improvement in the condition of women, as compared with men, and that it may be very accurately measured by this standard. Judging from the past, we may be sure that one of the paths for the future progress of the race lies in this improvement, and the position of women must therefore be regarded as a most important social problem. If there is, as I shall try to show, a fundamental and constantly increasing difference between the sexes; if their needs are different, and if their parts in the intellectual, moral, and social evolution of the race, are, like their parts in the reproductive process, complemental, the clear recognition of this difference must form both the foundation and superstructure of all plans for the improvement of women.

If there is this fundamental difference in the sociological influence of the sexes, its origin must be sought in the physiological differences between them, although the subject is now very far removed from the province of ordinary physiology. While we fully recognize the insig-

nificance of the merely animal differences between the sexes, as compared with their intellectual and moral influence, it is none the less true that the origin of the latter is to be found in the former; in the same manner—to use a humble illustration—that the origin of the self-denying, disinterested devotion of a dog to his master is to be found in that self-negation which is necessary in order that a herd of wolves may act in concert under a leader, for the general good.

In order to trace the origin and significance of the differences which attain to such complexity and importance in the human race, we must carry our retrospect back far beyond the beginning of civilization, and trace the growth and meaning of sex in the lower forms of life. In so doing I shall ask attention to several propositions which may not at first appear to have any bearing upon our subject, or any very close relation to each other. I shall then try to show what this relation is, and point out its bearing upon the education of women.

Every organism which is born from an egg or seed is a resultant of the two systems of laws or conditions, which may be spoken of abstractly as the law of heredity, and the law of variation, or, to use the old teleological terms, each organism is a mean between the principle of adherence to type and the principle of adaptation to conditions.

That like produces like is universally but never absolutely true. The offspring resembles its parents in all fundamental characteristics. The human child, for instance, resembles its parents in the possession of all the characteristics which distinguish living things from not living, as well as those which distinguish animals from plants. The chemical, physical, and physiological changes which take place in its body and the histological structure of its tissues are like those of its parents, and its various organs are the same in form and function. All the characteristics which unite it with the other vertebrates, as a member of the sub-kingdom Vertebrata, are like those of its parents, and also those which place it in the class Mammalia, and in its proper order, family, genus, and species. It also shares with its parents the features or race characteristics of the particular tribe or race to which they belong. If they are Chinese, Indians, or negroes, the child belongs to the same race, and manifests all the slight, superficial peculiarities of form, constitution, and character by which that race is characterized. Even the individual peculiarities of the parents, intellectual and moral as well as physical, are now known to be hereditary. Since this holds true of any other animal or plant, we must recognize the universality of the law of heredity, but we must not overlook the equally well-established fact that each organism is the resultant of this law and another, the law of variation. The child is like its parents, but not exactly like them. It is not even a compound of characteristics found in one or the other of them, but has individual peculiarities of its own; slight variations which may not have existed in either parent, or in any more remote ancestor. The slight

individual differences are so overshadowed by the much more conspicuous resemblances due to heredity — with which they compare about as the green buds at the tips of the twigs of a large tree compare with the hard wood of the trunk and branches, the growth of previous years—and they are so fluctuating and inconstant, that their importance may easily escape attention. Careful observation shows, however, that every characteristic may vary: those distinctive of the class or order as well as those which mark the species or variety. The variations may manifest themselves in the adult, or at any other period in the life of the individual. Even the eggs have individualities of their own, and among many groups of animals the eggs of the same parent, when placed under precisely similar conditions, may differ in the rate and manner of development. Although most of these individual differences are transient, and disappear within a few generations, there can now be no doubt that those which tend to bring the organism into more perfect harmony with its environment, and are therefore advantageous, may be established as hereditary features, through the action of the law of the survival of the fittest; and it is hardly possible to over-estimate the value of the evidence which paleontology and embryology now furnish to prove that all hereditary characteristics, even the most fundamental, were originally individual variations.

The series of hereditary structures and functions which makes up the life of an organism is constantly being extended by the addition of new features, which at first were individual variations, and are gradually built into the hereditary life history. In this way newly acquired peculiarities are gradually pushed further and further from what may be called the growing end of the series, by the addition of newer variations above them. It can also be shown that from time to time the peculiarities at the other end of the series, the oldest hereditary features, are crowded out of the life of the organism, and dropped, so that an animal which is high in the scale of evolution does not repeat, in its own development, all of the early steps through which its most remote ancestors have passed. The series of hereditary characteristics, thus growing at one end and fading away at the other, gradually raises the organism to new and higher stages of specialization, and its evolution by variation and heredity may be compared with the growth of a glacier.

The slight individual differences are represented by the new layers of snow added by the storms to the deposit which fills the valley in which the glacier arises. The snows which are soon blown away are those variations which, being of no use, soon disappear; while the snow which remains in the valley, and is gradually converted into ice, represents those individual differences which are seized upon by natural selection, and gradually rendered hereditary and constant. The long stream of ice stretching down to lower regions, and made up of the

snows of thousands of winters, receiving new additions at its upper end, and at the same time melting away at its lower, is no bad representation of the long series of hereditary features, once variations, which form so large a part of every organism. If the glacier were not in motion, but stationary, so that the melting of the oldest portion and the additions to its upper end should gradually carry the body of ice up to higher and higher levels, we should have a very perfect parallel to the evolution of an organism by variation and heredity.

The steps in this progress are embodied in a long series of individuals, each of which is, either immediately or indirectly, the product of a fertilized egg or seed, through which the laws of heredity and variation act, to bind the separate individuals into a progressive whole. The seeds and eggs with which we are most familiar are highly complicated, and consist of the protoplasmic germ, which is intimately united to a mass of food destined to be converted into protoplasm during development.

The germ with its food forms the yolk of such an egg as that of the bird, and is surrounded by layers of albumen, which are also used as food, and by a complicated series of investing membranes. It originates in a special organ, the ovary, and is incapable of perfect development until it has been fertilized by the male reproductive element. In its earliest stage of growth it is simply one of the cells or histological elements of the ovary, but as it grows it soon becomes very much larger than an ordinary cell, and its protoplasm becomes filled with food material, and the outer layers and walls are added to it. In many animals, the external envelopes are wanting, and the egg is simply a very large ovarian cell, filled with food material, and capable of developing, under the influence of the male element, into a new organism. In still other animals the food-yolk is wanting, and the egg is small, and does not differ from an ovarian cell; and in still other animals the ovaries are lacking, and cells may become specialized as ova in various parts of the body.

The series is so complete that we may be certain that we are comparing strictly homologous structures, and we may therefore conclude that the egg is nothing but one of the cells of the body, which may, when acted upon by the male element, develop into a new organism, substantially like its parents, with some of the individual peculiarities of each of them, and also with new peculiarities of its own.

From the necessity for impregnation in most cases, it has been assumed that the essential function of the male element is to quicken the germ, and thus start the process of development. It is true that it does have this function in many cases; but comparative study shows that the egg itself is alive, and does not need quickening, and that this must be regarded as a secondary and derived function of the male element, not the essential and primitive function.

That this is the case is shown by the fact that, while the earlier

stages in the developmental process are sufficiently alike in different animals to admit of a comparison between them, the stage at which impregnation takes place is not fixed, but variable. In some cases the ovarian egg remains without change until it is impregnated; and the first step in the developmental process, the disappearance of the germinative vesicle, is the immediate result of the union of the spermatozoa with the ovum. In other cases the germinative vesicle disappears, and the egg then remains inactive until it is impregnated; and this is followed at once by segmentation. In still other cases segmentation takes place without impregnation. Other eggs develop still further; and, finally, there are many animals whose unfertilized eggs not only commence, but complete the developmental process, and give rise to adults which may in turn produce young in the same way: and this may go on indefinitely, without the intervention of a male. The queen bee is able to lay fertilized or unfertilized eggs at will, and they are equally alive and capable of development.

These facts show conclusively that the essential function of the male element is not the vitalization of the germ.

Turning now to another aspect of our subject, we find that among plants, and among all the lower and simpler groups of animals, new individuals are produced by the various forms of asexual generation, as well as sexually. In certain animals, such as the tunicates, this form of generation is highly specialized, and the stolon from which new individuals are budded off is a highly complex structure, which contains cells or tissues derived from all the essential organs and systems of the parent, and from these the corresponding organs and systems of the new individual are derived. As a rule, however, the process of budding is very simple: a mass of unspecialized cells at some definite point upon the body of the parent, animal or plant, becoming converted into a new individual, instead of contributing to the further growth of the old. Among the lower animals, such as the hydroids and sponges, the process is still more simple, and cells may become converted into a bud at almost any point upon the body of the parent. That the process of reproduction by budding is not in any way absolutely distinguished from the process of ordinary growth by cell-multiplication, is shown by the fact that an accident may determine which of these processes is to result from the activity of a given cell.

Comparison shows that there is, on the one hand, no essential distinction between ordinary growth and reproduction by budding, and, on the other hand, none except the necessity for impregnation to distinguish asexual from sexual reproduction. All these processes are fundamentally processes of cell-multiplication. As none of the animals with which we are thoroughly familiar reproduce asexually, we are unable to make any very exact comparison of the results of the two processes of reproduction in animals; but among plants such com-

parison can be made without difficulty, and will be found to show that variation is much more marked and common in plants raised from fertilized seed than in those raised by budding. A marked bud-variation is of very rare occurrence, but in many cases the tendency of plants raised from seeds to differ from the parents is so great that choice varieties are propagated entirely by buds. It is almost hopeless to attempt to propagate a choice variety of grape or strawberry by seeds, as the individuals raised in this way seldom have the valuable qualities of their parents, and, although they may have new qualities of equal or greater value, the chances are of course greatly against this, since the possibility of undesirable variation is much greater than the chance of a desirable sport. There is no difficulty, however, in perpetuating valuable varieties of these plants by asexual reproduction.

Putting together these various propositions—that the evolution of life has been brought about through the combined action of the law of heredity and the law of variation; that in all except the simplest organisms the process of sexual reproduction by ova which have been acted upon by the male element is met with; that the ovum is alive, and capable of development in itself, and that the essential function of the male element is something else than the vitalization of the ovum; that the process of sexual reproduction differs from the process of asexual reproduction only in the occurrence of impregnation, while the result of the former process differs from the result of the latter in its greater variability—we seem warranted in concluding that the ovum is the material medium through which the law of heredity manifests itself, while the male element is the vehicle by which new variations are added. The ovum is the conservative, and the male element the progressive or variable factor in the process of evolution of the race as well as in the reproduction of the individual. The adequate statement of the evidence upon which this generalization rests, or even a full statement of the generalization itself, with its qualifications, would be out of place here, but the facts which have been given seem to be sufficient to warrant its use as one step in our argument in regard to the relations of the sexes. From this as our basis we will now trace the evolution of sex.

Among the lowest organisms, animal and vegetable, multiplication is usually by the various forms of asexual generation, budding or fission, or cell-multiplication—an organism which has by ordinary growth increased in size beyond the limit of exact harmony with its environment, dividing in this way into two, like each other as well as like their parent. In this way the preservation of the established characteristics of the species—heredity—is provided for, but in order that progress should take place, by the preservation of favorable varieties, variation must also be provided for. This is accomplished by the process which is known as conjugation: two protoplasmic organisms approach, come into contact, and a transfusion or mixture of the

semi-fluid contents of their bodies takes place. The result of this process is the production of new individuals which, deriving their protoplasm from two parents which are not exactly alike, are themselves different from either of them, and have individual peculiarities which are, it is true, the resultant of the peculiarities of the parents, but which are nevertheless new variations.

In the simplest forms of conjugation the functions of both parents appear to be identical, but in organisms which are a little more specialized we find male and female reproductive bodies, and the offspring is the result of the union of the male element of one individual with the female element of another; that is, we have true sexual reproduction in its simplest form.

Among the lower animals and most plants both sexes are united in the same individual, but the law of physiological division of labor, the principle that an organ or organism, like a machine, can do some one thing better and with less expenditure of force when it is specially adapted to this one thing than when it is generally adapted for several functions, would lead to the preservation by natural selection of any variations in the direction of a separation of the sexes, and we should therefore expect to find among the higher animals what we actually do find: the restriction of the male function to certain individuals, and the restriction of the female function to others. From this time forward the male is an organism specialized for the production of the variable element in the reproductive process, and the female an organism specialized for the production of the conservative element. We soon meet with structural peculiarities adapted to aid and perfect the performance of these respective functions; and the various organs, habits, and instincts by which, among the higher animals, the rearing of young is provided for form one of the most interesting chapters of natural science. On *a priori* grounds we should expect a still greater specialization to make its appearance. Since the male organism has for its function the production of the variable reproductive element, and since variations which originate in a male have their perpetuation especially provided for, it would clearly be of advantage that the male organism should acquire a peculiar tendency to vary, and any steps in this direction would accordingly be seized upon by natural selection and perpetuated. The female organism, on the other hand, having for its function the transmission of the established hereditary features of the species, we should expect the female to gradually acquire a tendency to develop these general characteristics more perfectly than the male. The male organism would thus gradually become the variable organism, as well as the transmitter of variations, and the female organism would become the conservative organism, as well as the originator of the conservative element in reproduction.

The study of the higher forms of life shows that this specialization

has actually taken place in many cases, and that, in nearly all cases in which the sexes differ in peculiarities not actually concerned in reproduction, the male has varied more than the female. The amount of variation which any organism has lately undergone may be learned in two ways—by a comparison of allied species, and by a comparison of the adult with the young. In a genus which comprises several species the characteristics which these species have in common are due to heredity from a common ancestor, and are therefore older than features which are confined to any one species. Now, it is a well-known ornithological law that the females of allied species of birds are very much more alike than the males, and that in some cases where the females can hardly be distinguished the males are very conspicuously different—so much so that there is not the least danger of confounding them. Countless examples will present themselves to any one who is at all familiar with birds, and those who are not can at once find ample proof by glancing through any illustrated work on ornithology —Gould's "Humming-Birds," for example.

The greater variability of the male is also shown by a comparison of the adult male and female with the immature birds of both sexes. Since the growing animal tends to recapitulate, during its own development, the changes through which its ancestors have passed, substantially in the order in which they first appeared, it follows that, in cases where the sexes are unlike, the one which is most different from the young is the one which has varied. Now, it is only necessary to compare the nearly full-grown young of our domestic fowls with the adult cock and hen, to perceive that the adult hen agrees with the young of both sexes in lacking such male characteristics as the highly ornamented tail-feathers, the briliant plumage, the distended comb, the spurs, and the capacity to crow. Countless similar illustrations might be given to show the great tendency of the male to vary, but the above are sufficient for the purposes of our argument. As both sexes usually retain the more general specific and generic characteristics, and are alike as far as these are concerned, it is a little more difficult to show the conservative constitution of the female than it is to prove the male tendency to vary. Among the Barnacles there are a few species the males and females of which differ remarkably. The female is an ordinary barnacle, with all the peculiarities of the group fully developed, while the male is a small parasite upon the body of the female, and is so different from the female of its own species, and from all ordinary barnacles, that no one would ever recognize, in the adult male, any affinity whatever to its closest allies. All of the hereditary race characteristics are wanting: the limbs, digestive organs, and most of the muscles and nerves have disappeared, as they are not needed by a parasitic animal; and the male is little more than a reproductive organ attached to the body of the female. It is only when the development of the male is studied that we obtain any proof of its

specific identity with the female. The young of both sexes are alike, and the developing male shares with the female the characteristics which unite them to the other barnacles, and which are due to descent from a common form. The female keeps these hereditary characteristics through life, while the male soon loses them entirely.

These facts seem to be sufficient to prove that the specialization which we should expect to find among the higher animals with separate sexes does exist, and that the male organism is especially and peculiarly variable, and the female organism especially and peculiarly conservative.

Leaving this aspect of our subject for the present, let us look at it from a somewhat different point of view. The history of the evolution of life has not only an objective side, but something which may with perfect propriety be spoken of as a subjective aspect. The progress which is shown objectively as greater and greater specialization of structure, and a closer and closer adaptation of the organism to the conditions of the external world, has been well described by Herbert Spencer, as the increasing delicacy, exactness, and scope of the adjustment between internal and external relations. Seen in its subjective aspect, each of the steps in the growth of this adjustment is a recognition of a scientific law, the perception of the permanency of a relation between external phenomena; for science is simply the recognition of the order of nature.

When a Rhizopod discriminates between the contact of a large body and that of a small one, and draws in its pseudopodia and shrinks into as compact a shape as possible in order to escape the danger which the past experience of the race has shown to be related to the former sensation, or when it expands its pseudopodia in order to ingulf and digest the body which has caused the second sensation, it furnishes proof that its scientific education has begun. Of course I do not intend to say that the order of nature, according to which the Rhizopod adjusts its actions, is consciously apprehended, but simply that it is the experience of the existence of this order which determines the action. Throughout the whole course of the evolution of one of the higher organisms each variation which served to bring about a closer harmony between the organism and its environment, and was accordingly preserved by natural selection, and added on to the series of hereditary structures and functions, was in its subjective aspect the experience of a new external connection, a new step in the recognition of natural law, an advance in scientific knowledge. Human advancement is of course widely different from the slow progress of the lower forms of life, but it is fundamentally the same. Experience is continually spreading over new fields, and bringing about a more wide and exact recognition of the persistent relations of the external world. The scientific laws thus recognized then gradually take the shape of principles or laws of conduct, according to which actions

are determined in those cases where experience has shown that they apply. Those laws of conduct which have been long recognized gradually assume the shape of habits or intuitions, according to which conduct is almost unconsciously regulated, and the habits finally become established as one of the hereditary characteristics of the race.

We are apt to confine our attention to the subjective side of human advancement, and to neglect the structural side, and at the same time to neglect the subjective side of the evolution of the lower forms of life, and to confine our attention to the structural side, but of course no one can doubt that a new habit is represented by a new specialization of structure, and is transmitted like any other peculiarity by heredity.

If this is so, and if the female organism is the conservative organism, to which is intrusted the keeping of all that has been gained during the past history of the race, it must follow that the female mind is a storehouse filled with the instincts, habits, intuitions, and laws of conduct which have been gained by past experience. The male organism, on the contrary, being the variable organism, the originating element in the process of evolution, the male mind must have the power of extending experience over new fields, and, by comparison and generalization, of discovering new laws of nature, which are in their turn to become rules of action, and to be added on to the series of past experiences.

Our examination of the origin and significance of the physiological differences between the sexes, and of the parts which they have taken in the progress of the past, would therefore lead us to expect certain profound and fundamental psychological differences, having the same importance; and it will be interesting to examine what these intellectual and ethical differences are, and how far experience and the common consent of mankind accord with the demands of our hypothesis.

If, as we suppose, the especial and peculiar function of the male mind is the expansion of our circle of experience; the more exact apprehension of all our relations to the external world; the discovery of the laws of thought, of society, of physiology, and of the material universe, and of the bearing of these laws upon individual conduct—it will follow that men must excel women in their power to discover the manner in which a new external relation shall be met and provided for by a new internal adjustment. In a case where our instincts, intuitions, feelings, or past experiences furnish no guide to conduct, the judgment of a man as to the proper course of action will be of more value than the judgment of a woman.

On the other hand, only a very small proportion of our actions are directed to new conditions; experience has already determined the proper conduct in all the circumstances upon which our preservation and well-being most directly depend; and action in these circumstances does not demand comparison and judgment, while it must usu-

ally be so prompt as to forbid deliberation or thought. The power of quick and proper action in the innumerable exigencies of ordinary life, independent of reflection, is at least equally important with the power to extend our field of rational action.

By the former power we hold on to what has already been gained, while the latter power enables us to increase our advantage in the struggle for existence, and to widen our control over the laws of nature. Psychological variation is the result of the latter power, psychological heredity the result of the former, and psychological evolution and human progress the result of their combined action.

If the female mind is especially rich in the fruit of this past experience, we should expect women to excel men in the promptness and accuracy with which the conduct of ordinary life is decided, and in the range of circumstances over which this power of rational action without reflection extends; that is, we should expect men to excel in judgment, women in common sense.

This important and fundamental difference between the male intellect and the female must have a very great influence in determining the occupations or professions in which each sex is most likely to succeed when brought into fair competition with the other sex.

The originating or progressive power of the male mind is shown in its highest forms by the ability to pursue original trains of abstract thought, to reach the great generalizations of science, and to give rise to the new creations of poetry and art. The capacity for work of this character is of course very exceptional among men; and, although history shows that it is almost exclusively confined to men, it must not enter into our conception of the ordinary male mind. The same power of originating and of generalizing from new experiences is possessed, in a lesser degree, however, by ordinary men, and gives them an especial fitness for and an advantage over women in those trades, professions, and occupations where competition is closest, and where marked success depends upon the union of the knowledge and skill, shared by competitors, to the inventiveness or originality necessary to gain the advantage over them.

Women, on the other hand, would seem to be better fitted for those occupations where ready tact and versatility are of more importance than the narrow technical skill which comes from apprenticeship or training, and where success does not involve competition with rivals.

The adequate examination of this aspect of our subject would furnish material for a treatise, and it is out of place here, as all that is necessary for the purposes of our argument at present is to point out the difference, and to show that it is the necessary consequence of our view of the manner in which sex has been evolved: that it is not due to the subjection of one sex by the other, but is the means by which the progress of the race is to be accomplished.

[*To be concluded next month.*]

SELECTING A FIRST MERIDIAN.*

By E. CORTAMBERT.

EVERY one knows that what is called a *first meridian* is the circle from which we start in reckoning longitudes. It were better to call it an *initial meridian*, or *zero meridian*, for the *first* meridian is not in reality this one, but the first we meet in longitude starting from zero, i. e., at sixty minutes from this starting-point. We should prefer to adopt the term *mediator*, as proposed by M. Bouthillier de Beaumont, it being analogous to the term *equator*, which is the starting-point in reckoning latitudes.

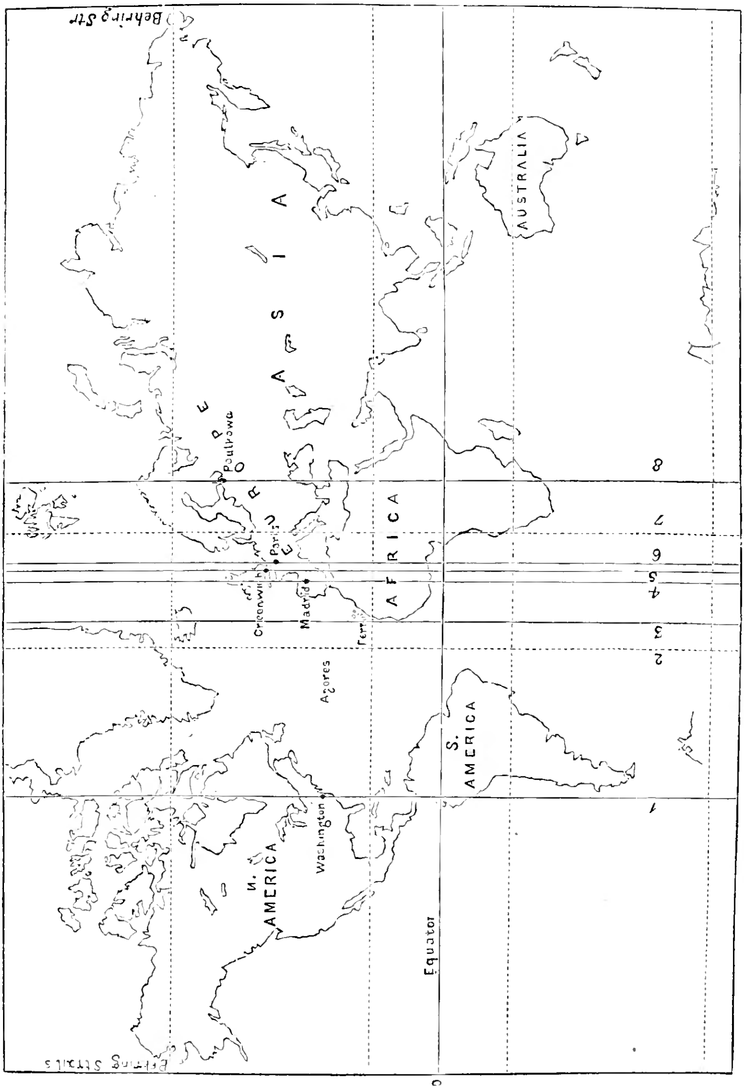
This matter of a first meridian gives rise to very grave complications. Each nation wants to have its own meridian passing through its capital city, or its principal observatory. Hence result numerous difficulties, errors, even dangers and accidents to ships, in case we are not sure about the meridian employed, or if we are in error in our reckoning of the difference between one meridian and another.

The geographical knowledge of the ancients extended on the west only as far as the Canary Islands. From here, or hereabout, Ptolemy started in reckoning longitudes, going eastward to the limit of the countries then knowm. This western limit of his geographical knowledge he reckoned to be 60° west of Alexandria—a calculation which would place the starting-point a little to the west of the Canaries. According to Ptolemy's geography, Paris is in longitude $23\frac{1}{2}°$, and hence the starting-point could not be the most westerly isle of the Canary group, as has usually been supposed, but farther to the west. Nevertheless, to do away with all uncertainty, an ordinance of Louis XIII., in 1634, declared that French geographers must start from the isle of Ferro. But what was the precise situation of this isle? It was at first held to be $23\frac{1}{2}°$ from Paris, and this erroneous calculation has given rise to strange variations in the position of the first meridian in a great number of maps.

In 1682 the observations of Varin and of Deshayes gave the longitude of Ferro as 20° 5′ west of Paris, and thenceforward the round number of 20° was taken to be the distance between these two meridians. Still many geographers, among them Delisle himself, who had been one of the first to make known the precise longitude of Ferro, continued to reckon the distance at $23\frac{1}{2}°$, after Ptolemy. Sometimes they corrected this reckoning, reducing it to $22\frac{1}{2}°$, or even to $20\frac{1}{2}°$. In 1711, in a map of the Île de France (Mauritius), Delisle places Paris in longitude 20° exactly, but the same geographer by a very strange anomaly, in a map bearing date 1717, adopts the figure 22° 30′. In fact, it

* Translated from "La Nature," by J. Fitzgerald, A. M.

was not till the middle of the eighteenth century that, chiefly through the influence of D'Anville and the Cassinis, the precise difference of 20° was definitively adopted. The well-earned fame of the French geographers gave to their determination authority throughout Europe, and



First Meridians.—1, Washington; 2, St. Michael; 3, Ferro; 4, Madrid; 5, Greenwich; 6, Paris; 7, Bouthillier de Beaumont's; 8, Poulkowa.

all the nations accepted this distance and the meridian of Ferro, except England, which fixed her first meridian at St. Paul's in London, and later at Greenwich. In France the meridian of Paris came to be reckoned as first meridian from the publication of Cassini's map. The

first important maps, besides Cassini's, which adopted the Paris meridian were that of Capitaine (1789), and that of De Belleyme (1791).

This over-patriotic selection by the English and French was a bad precedent. The Low Countries must have their meridian at Amsterdam, the Spaniards at Madrid (having previously tried Teneriffe and Cadiz), the Portuguese at Lisbon, the Russians at the Poulkowa Observatory, the United Sates at the Washington Observatory, the Chilians at Santiago, the Brazilians at Rio de Janeiro, and so on.

These divers pretensions are deplorable, and cause no end of confusion, and it is time that a single meridian were established. M. de Chancourtois, in his "System of Geography," which was presented to the Paris Geographical Society in 1874, proposed to adopt the meridian of the island of St. Michael, in the Azores, which he holds to have been Ptolemy's first meridian; which was the meridian adopted by Mercator; and which to him appears to be preferable to all other meridians because it traverses the ocean throughout one-half of its length, and in the other half only touches the eastern extremity of Asia, thus constituting a sufficiently exact dividing line between the two main continents, the old and the new. The late M. Henri Longpérier proposed a meridian traversing the center of Europe, crossing Dalmatia and the Adriatic, and pretty accurately dividing the Eastern from the Western world.

Again, it has been proposed to establish the first meridian at Jerusalem, that center of high and honored memories; but perhaps, just on account of the religious associations, such a selection would not be approved by all nations. For our own part, we confess that we are partisans of the project offered by M. Bouthillier de Beaumont, President of the Geneva Geographical Society to the International Congress of Commercial Geography at Paris in 1878. This learned geographer proposes the selection of the meridian passing through Behring Strait on the one side of the globe, and 10° east of Paris on the other. It would on the one hand separate the two great continents, and on the other would in Europe follow the line of demarkation between the "Eastern" and the "Western" nations.

We highly approve this idea of fixing the first meridian exactly 10° east of Paris: the conversion of determinations of longitude reckoned from Paris and Ferro—which are very numerous—would be thus facilitated. This meridian would pass through Venice and would be very near to Rome, both places dear to the historian and of profound interest to the geographer. Nevertheless, we must not take for the starting-point a place belonging to any particular state, for fear of exciting again those national rivalries which have led to the fixing of such a number of national meridians. But the *mediator* which we propose, in unison with M. Bouthillier de Beaumont, passes also through the island of Levanzo, off the west coast of Sicily. Might not the Italian Government cede this islet to the world of science, to form the site

of a central and international observatory? The place might be the common property of all the civilized nations which might agree to its acquisition; for, we repeat, it must be neutral ground, a position independent of all political power, and under guarantee of all the states of the civilized world. The 180th degree would traverse Cape Prince of Wales, where it projects into Behring Strait, and this and the island of Unalashka in the Aleutian Archipelago are the only points where it would touch land. The United States, following the example of Italy, might cede to the republic of science this cape or a part of Unalashka, to be the site of an observatory in correlation with that of Levanzo.

THE STUDY OF PHYSICS IN THE SECONDARY SCHOOLS.

By JOHN TROWBRIDGE,
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PHYSICS is a comprehensive term for the laws of the physical universe, and is gradually superseding the old term natural philosophy which held together in a disconnected manner various facts in mechanics, light, heat, sound, electricity, and magnetism. Under the head of Natural Philosophy most of us were taught that a body falling from the vertex of an inclined plane acquires the same velocity as it would if it rolled down the plane. A considerable knowledge of mathematics was required to prove this fact, and the youthful mind could hardly see the bearing of it when it was demonstrated. We were shown what we learned to call the falling machine of Atwood, which proved simple laws with such ponderousness of structure and complexity of appliances that even the name of the machine made more impression upon the memory than the laws of which it was the servant. The brightest boys could prove that the square of the velocity of a falling body was equal to twice the acceleration of gravity multiplied by the height through which it had fallen, and the rest of us mutely followed the rule, and substituted in a formula which was forgotten as soon as the exigencies of school life were over. We also carried away vague recollections of a pump which worked by means of a curiously constructed valve. We had forgotten whether the center of gravity is where the center of pressure is applied, or where specific gravity exerts itself. We remembered a tuning-fork, an electrical machine, and a big electro-magnet which lifted the smallest boy in school, and that was all that we remembered of natural philosophy. At that very age most of us, if not all, were curious about air and water, the motions of the earth and the moon, the light of the stars,

the curious manifestations of frost, fire, and electricity and magnetism. I remember how glibly we recited portions of natural philosophy where the author forgot his grim mood for a moment, his triangles and square roots, and explained in a simple manner why the rising moon appeared so large between the small branches of a wood, and why fog came up the bay when the sun went down. When we succeeded in getting the right answer to a problem we were elated and began to think that natural philosophy was not so difficult to study, after all; but these moods of elation were too often succeeded by those of blackest night and incendiary desires. In looking back, the thought comes to us that there must have been something radically wrong in such teaching; for the subject of the laws of the physical universe has such infinite possibilities and contains so much that can stimulate the imagination of even young children, that any method which represses, or does not encourage a child's desire to know the reason of things, must be radically wrong.

It must not be supposed, however, that the picture we have presented has not its bright side: there are always teachers who are especially interested in physical science, and who excite an interest in the subject among their pupils. The hour of the lecture on physics is looked forward to by the pupils of some schools with great relish, and some date their interest from the school exercises in this branch. Generally speaking, however, most men who have more than the ordinary knowledge of science have had their enthusiasm awakened out of school, and by actually working with apparatus, or handling specimens, have taught themselves.

The opponents of the study of physics in the secondary schools generally regard it as of less importance than the mathematical or grammatical studies, and class it among what they regard as superfluous subjects, the number of which has very much increased of late years. Not a few of these remember the manner in which they were taught, and have no desire that their children should repeat their experience. It is very natural also that the teacher whose training has been exclusively literary should be indisposed to teach a subject like physics, which requires a certain facility with apparatus and some inventiveness which a purely literary training has the effect of obscuring and even crushing out. Who has not seen an excellent teacher in the languages or even in mathematics fail completely before a class of boys and girls in showing some simple experiment? It is very natural that he should fail, for this facility and inventiveness of which we have spoken come, except to the few, only by practice and from an early habit of observation. More time also is consumed in getting ready for one lecture or exercise in physics than in six recitations in the straightforward subjects of language and mathematics. A refractory piece of brass, a wire wanting here and there, a shrunken bit of bladder, a broken glass tube, may involve hours' labor for one who is gen-

erally hard-worked in other ways. It is easy to theorize on the subject of teaching science, especially physical science, in the second grade of schools, but one should not forget the wearing nature of routine work which is apt to deaden one's enthusiasm. One can not expect a teacher to hold weekly talks with his pupils on force, or to rely upon treatises which are merely descriptive, or to be patient with apparatus which, by frequent use, seems almost puerile, without giving him also a comparatively rigid standard in the shape of a book by which he can advance in a more or less mechanical manner. Many teachers, therefore, comply with the letter of the law, and with one of the many text-books called Natural Philosophy shorten the popular exposition of the subject to a minimum and demand a certain number of problems under the lever, the screw, the inclined plane, and the pendulum. This mechanical teaching succeeds to a certain extent with the bright boys of some methematical tendencies; but it fails with the great majority, who speedily get a disgust for the whole subject. To add to the teachers' difficulties, many of them have not a sufficient knowledge of the subject to enable them to courageously reject the descriptions of machines with which many text-books are filled, in which the principles are lost sight of in a multiplicity of levers, pulleys, and connecting pieces.

In teaching a language or a branch of mathematics in a grammar school, one has all his materials ready at hand, a certain author, a certain dictionary, a grammar. In teaching physical science, almost every text-book requires to be supplemented by some apparatus which is not provided with the text-book, and contrivances must be resorted to, and judgment must be used in regard to aids in teaching upon which experience seems to be very indefinite. There are wide limits in regard to the cost of this or that piece of apparatus, and difficulties in deciding between instrument-makers. Very often there is no one available to repair an instrument, and the instruction has an added tendency to become mechanical.

On the other hand, there are enthusiastic teachers who are imbued with the modern popular method of teaching physics by the aid of a lime-light stereopticon. Small appropriations are saved until an expensive instrument can be obtained; and what may be called a college course in physics is inaugurated in the second grade of schools. It is a laudable ambition to desire to illustrate the subject of physics by the method of projections; but the policy of expending from one to two hundred dollars for a lime-light for the use of a grammar or even a high school is questionable.

Professor Mayer, in his excellent little books on the experimental study of light and sound, shows how a water lantern can be constructed for three dollars, which answers every purpose; and if there is no sunlight one of the many forms of kerosene lanterns is admirable for showing diagrams, the deflections of a galvanometer, crystallizations, and minute experiments which a class could not otherwise see

to advantage. With the aid of such a cheap method of projection, a grammar-school master can give quite an extended course in physics with simple apparatus. He can draw his own diagrams on smoked glass, fixing the drawing by exposing it to the vapor of alcohol, which is evaporated from a shallow dish; and for the money which is expended for a lime-light apparatus enough apparatus can be bought which, supplemented by a water or a kerosene lantern, would illustrate a full course of elementary lectures on physics. In many school collections of apparatus, a few expensive instruments will be found: an air-pump; a Holtz electrical machine; a large induction coil. One or two of such instruments form the rallying point of the department of physics, and are accompanied by meager and disjointed apparatus. The student collects, so to speak, his thoughts about the picture of a complicated machine; his ideas of the pressure of gases or rarefied air are complicated by the imperfect remembrance of certain valves. Electricity of high tension means something evoked by an electrical machine. These pieces of apparatus which I have mentioned form a salient point of attack upon the system of instruction in physics too common in many schools. A good air-pump is difficult to keep in order, and finds its true place only in the private laboratory of an investigator, or in a college collection of apparatus. In the secondary grade of schools some form of Sprengel's pump, or, where there is an available head of water, an aspirator, will illustrate varying pressures sufficiently well. The new Holtz machine which schools are anxious to possess can only serve as a toy, for the theory of its working is very hard to comprehend even by those who have studied the subject in mature years.

The modern view of the physical universe is that there is no such state as rest: the particles of a gas are in an incessant state of motion, and it can be maintained that when a stone rests upon a table it is not at rest; for it is forced downward by the action of gravitation through a very small distance, and the elasticity of its support tends to move it upward through the same distance. The term statics is apt to be misleading, and the best writers on science of to-day begin treatises on natural philosophy with the subject of dynamics or forces in motion. In no subject, however, is the division into statics and dynamics so illogical as in the subject of electricity. In most schools a student begins the study of this subject with frictional electricity and the electrical machine. An advanced student in a university pursues the opposite plan, and approaches the subject, even if it be for the first time, from the standpoint of the voltaic cell, and traces the development of the force up to the point of the generation of electricity similar to that produced by an electrical machine. Very little knowledge can be obtained from the exhibition of toys like dancing pith-balls, insulated stools, miser's plates, and apparatus for obtaining shocks.

The method of instruction in physical science, therefore, in the secondary grades of schools, seems to me to be too costly and not sufficiently logical. The remedy does not consist in curtailing the amount of attention paid to the subject in the lower schools, or in relegating it to a more advanced period of education. It is more reasonably embraced in leading teachers to seek simpler methods of instruction, simpler apparatus, and to avoid abstruse conceptions, and the solution of mechanical problems for which mere formulas are given. It would be well, also, if the best students are led to experiment themselves, and are stimulated to observe. This is hardly possible in crowded grammar schools; but the excellent little treatises of Professor Mayer on experimental physics would lead many children, under proper encouragement from their teachers, to try simple experiments at home.

An ideal method of teaching physics in the secondary grade of schools would consist in developing the whole subject from the standpoint of motion, insisting upon the larger facts, correlating them as far as possible, and neglecting special applications and special facts. A number of interesting experiments can show that work must be done in all cases to produce work, and that motion can be changed into heat, and heat into motion. The student's mind should be tempted to take, at the very beginning of his study of the subject, an extended view of the application of the law of the conservation of energy. While treating the subject of force, a little descriptive astronomy can be given which will aid in stimulating the imagination. The subjects of heat and acoustics can be taught purely under the head of mechanics, with a variety of most interesting and simple experiments. I am inclined to place the subject of electricity and magnetism under the same head; and, beginning with the fact that electricity is generated by a voltaic cell, I should trace its simple manifestations until they conduct one to the law that all motion can be converted into electricity, and that electricity can be entirely converted again into heat and light. Having then shown that light can be produced by motion, the undulatory theory can be cautiously introduced. As a review of the subject of physics, one could take as a text the impossibility of perpetual motion, and enforce it with a variety of illustrations. The utility of the study of physics in the grammar schools is often questioned, and indeed the larger question of the value of scientific training except to the few in the world at large is often mooted. There is no doubt that the study of the humanities, in which the great story of men's deeds in the past is recorded, will always prove the most fascinating to the majority; and it can be maintained with reason that those subjects which readily excite an interest in the largest number will prove the readiest means of intellectual training. Science is regarded by many scholars merely as a practical branch of human knowledge, and, although its great value in contributing to the good of the world is acknowledged, yet

its study is regarded as inferior in intellectual results to that of language or philosophy. It can not be denied, however, that the study of physical science gives a certain definiteness to our modes of thinking, even if it will not be granted that it affords a better method of intellectual training than philological study. It supplies a tonic which minds much accustomed, from the exclusive study of language, to take things for granted and to look no further than the grammar and dictionary stand much in need of, and also corrects a certain credulity and superstition which is rampant even in our time, and to which it is well to devote a few words in connection with the subject of scientific training. There is a strong undercurrent of superstition and belief in supersensible or wonderful and not-to-be-explained marvels which makes its way beneath the crust of society. Occasionally it bursts forth in so-called manifestations of spiritualism and animal magnetism, or belief in mesmerism and clairvoyance. There is hardly a family of which some member has not applied to a clairvoyant for relief in diseases which the regular practitioner has failed to treat successfully. A literary education does not cope successfully with the insidious advances of this form of ignorance; for the very element of education which can do so is not generally cultivated among even so-called liberally educated persons. This lost element is the spirit of investigation. The students who come to a physical laboratory for the first time can be rapidly classified into three classes: 1. Those who can reason from A to B over what may be termed a straight line with considerable ease. 2. Those who naturally reverse their process of reasoning and test the way from B to A; this is a rarer class of minds. Copernicus was unable to explain the motions of the planets by supposing that all the visible stars revolved around the earth; he reversed his process of reasoning, and explained the facts by supposing the earth to turn and the stars to remain at rest. Kant, in his "Critique of Pure Reason," speaks of the revolution which he had brought about in philosophy, and likens it to the logical process which led Copernicus to his discovery. "Hitherto," he says, "it had been assumed that all our knowledge must regulate itself according to the objects; but all attempts to make anything out of them *a priori*, through notions whereby our knowledge might be enlarged, proved, under this supposition, abortive. Let us, then, try for once whether we do not succeed better with the problems of metaphysics, by assuming that the objects must regulate themselves according to our knowledge, a mode of viewing the subject which accords so much better with the desired possibility of a knowledge of them *a priori*, which must decide something concerning objects before they are given us." In practical matters this process of reversals is often exemplified; the inventor of the sewing-machine finds that his needle will not work with the eye at one end, and accordingly reverses its position and is successful. 3. The third class comprises those who may be said to think

in directions at right angles to their previous method of thinking, and there may be minds which possess what is analogous to the 4th dimension in space—an ability to think in all azimuths. It is strange that there are so few psychological impostors in the world; for the first class of minds, those who only think from A to B when a new class of facts are presented to them, is very large. An ingenious man can make a small magnetic motor which apparently runs with only the assistance of permanent magnets, and by means of extremely small clockwork maintain the motion beyond the period which a mind of class 1 is willing to give to an observation. It would naturally occur to such a mind to take the motor to pieces and examine the casings or box. If it finds nothing, and perceives that, when the apparatus is put together and is placed by the inventor on his table, it still runs, the investigation ceases, and another story confirms the previous rumor of a new marvel. A mind of class 2 goes over the same process of reasoning, and moves the instrument to different points for fear of concealed mechanism under the table or in the wall. A skillful manipulator, however, can still edge the motor to a third or fourth position, where other concealed clockwork can be taken advantage of, and in this way exhaust the number of what may be termed linear combinations of the investigator. The success of impostors in spiritualism and of the fabricators of new motors which are built to delude people resides in this, that they restrict the liberty of this system of reversals, or the spirit of investigation.

Any plan of education which prevents a man or woman from becoming the dupe of those who pretend to use natural or supernatural forces is to be commended. One of the quickest ways of training the mind in the logical process which I have indicated is to undertake some simple investigation in physics. Here mere observation is combined with a careful study of the interaction of various forces, and the mind must assign a logical weight to different observations. One truth, moreover, is forcibly brought forward—that, generally speaking, a number of observations under varying conditions must be made to prove the correctness of any result. The man who has been through the process will not be found among those who are convinced by a single manifestation of clairvoyance or of spiritualism. He will not spread the stories of a wonderful new motor until he has put it to an exhaustive test.

It would be well if our common schools made some provision for a certain amount of experimental work in physics to illustrate this method of studying. A great deal of education is comprised in the knowledge of how to change the conditions of an experiment in the process which I have termed a reversal, and also in the process of depending only upon a number of observations taken under different conditions. It would certainly be a great boon to the world if the general level of scientific education could thus be raised, so that each

young man or young woman, when he or she issues from school doors, should have enough definite knowledge of the great laws of the physical universe to instantly denounce blue-glass theories and attempts at perpetual motion, not from the pride of knowledge, but from the feeling that error, credulity, and superstition should be combated with truth.

MODERN SCIENCE IN ITS RELATION TO LITERATURE.

By WILLIAM BRACKETT.

THE innovations made by science upon other modes of thought and study within the last half century are without a parallel in the history of human progress. It has swept away many of our most cherished convictions, hoary with the dust of ages, and left others in their places entirely irreconcilable with them. Marching on with the might and majesty of a conqueror, it has spread dismay in the ranks of opposing forces, and caused a complete abdication in its favor of many of those who were most hostile to it. Nor has it taken the field in an aggressive or bellicose spirit. On the contrary, almost all its conquests have been made without any design of inspiring opposition or terror, and while engaged in pursuits that of all others require for their prosecution the most pacific and philosophic temper.

It might be easily shown by the comparison, were this essential to my design, that in the three great departments of human study, namely, those of science, religion, and literature, the cultivators of science have always shown a disposition to be more tolerant of opposition and more lenient toward their enemies than those engaged in either of the other pursuits. It might be shown that religious controversies, and the animosities engendered by them, hold the first rank in the scale of bitterness. Next come those of a literary nature, which, in the last century, were scarcely less implacable; while, with few exceptions, the great problems that have engaged the attention of scientists have been singularly free from heated and acrimonious discussion.

Much of this serene treatment of scientific subjects is due, no doubt, to their peculiar nature. In a given investigation the truth must, sooner or later, come to the light. Either the investigation will have to be abandoned altogether, because it is found to be beyond the province of the human understanding, or the problem will eventually be solved. In either event, long-continued doubt and uncertainty can not hang over the result. Hence few will venture, if so disposed, to cast ridicule upon efforts which may be crowned with success, and which may in the end expose the scoffers to similar reproaches.

Besides, the study of science, which is the study of nature, engages the mind in the study and contemplation of truth; and, as has been well said, "Truth is without passion." The little asperities, therefore, which ruffle other controversial natures, find scarcely any lodgment in the breast of him who searches after experimental truth. And such would be the effect produced upon the students of theology and literature were their conclusions capable of verification like those of the scientist. But, dealing for the most part with abstract subjects which in the nature of things can not be subjected to rigid mathematical tests, they find themselves afloat upon a wide sea of conjecture, in which faith and imagination are almost the only guides.

At this triumphant entry and career of Science upon the stage of modern thought, Religion is the only power that has as yet sounded the note of alarm, or assumed any very hostile attitude. Nor could she well do otherwise, because, one by one, she has seen her adherents falling away from her, and joining the ranks of her ostensible adversary, and, one by one, she has seen some of the fairest portions of her territory invaded, and either falling a prey to anarchy and dissolution, or rudely wrested from her. In vain she has cried out for help, or tried to throw up barriers against this invasion. The sapping and mining process has nevertheless gone on; so that, if in the next half century the progress of science shall make as great inroads upon the prevailing popular belief as it has made within the last, it is safe to predict that only a moiety of it will be left, or, what is more probable, it will be changed into something more consonant with the new scientific discoveries, and with what is called "the spirit of the age."

If the changes thus following in the wake of physical discovery have been so marked and significant upon one of the interesting branches of human knowledge to which allusion has been made, how has it fared with the other, which, if not so widespread in its influences, can not nevertheless be affected in its character or career without producing results of the greatest consequence? Has literature as well as religion felt the wand of the mighty magician? and is it likely, in the future, to be retarded in its growth, crippled in its strength, or to any extent diverted from its purpose by this onward and sweeping march of science? These are questions of so much importance that the candid consideration of them can not be without its interest if not without its profit.

The commonwealth of literature embraces many states and distinct divisions, of which only those are particularly referred to in these pages that are usually comprehended under the title of polite or elegant literature, including works of the imagination, such as poetry and fiction, as well as authentic narratives, set off, as in history, with the graces of polished composition. Limited to even this description, literature has performed such an important part in administering to

the instruction and delight of the world, that we could not afford to see it banished, even though a more efficient teacher should occupy its place. Nor can such a fate now in reality overtake it. Even should the number of its votaries ever be diminished, or should it ever fall into hands too feeble to sustain it, we would still have access to the ancient well-springs of its power, whose waters, though incapable of extension, can yet never run dry. It is a consolation to know that, though it may be impossible to add anything of sterling value to what has already been written, the great works of literary genius, treasured up in so many different languages, can never be taken away from us, and that their influence survives the manifold changes that happen to society in so many other respects.

Now, if it be true—that complaint of Labruyère—that "we are come into the world too late to produce anything new, that nature and life are preoccupied, and that description and sentiment have been long exhausted"; if it be true that literary labor, in times past, has spent itself in producing those wonderful creations which, by the common consent of mankind, stand as the highest models of composition and the highest types of literary excellence, then we must conclude that literature has reached its climax and fulfilled its mission, and that consequently there is no reason to regret its decadence. Better employ the measure of strength and talent with which we are endowed in exploring new lands and cultivating new soils than waste them in a field that is already gleaned of its harvests and exhausted of its fertility. To such a gloomy view of the present condition and future prospects of literature many men of sound judgment are unwilling to subscribe. And yet it seems to me, if they carefully consider the subject, especially in connection with the new direction which has been given of late years to the studies and aspirations of the noblest minds, they must see good reason for modifying their judgment. Let us examine it for a few moments with respect to two of the departments of letters that are regarded among scholars at least with the highest esteem and veneration of any—I mean poetry and history.

Those who are most familiar with the poetry of different countries, and of ancient and modern times, must admit the remarkable resemblance and repetition to be found in it. Under the garb perhaps of a new diction, in one poet, will be found lurking the identical idea expressed by another. As Emerson says: "The originals are not original. There is imitation, model and suggestion, to the very archangels, if we knew their history. The first book tyrannizes over the second. Read Tasso, and you think of Virgil; read Virgil, and you think of Homer; and Milton forces you to reflect how narrow are the limits of human invention." And as Dryden somewhere says about the modern poets, "You may track them in the snow of the ancients." Even the imagery and what is called the "machinery" of poetry repeat themselves in different ages, in the pages of different writers. The

only difference is in the language—the thought remains a constant quantity, being stereotyped and reproduced to suit the emergency.

Now, this perpetual recurrence of the same idea among different poets is often stigmatized as plagiarism. But such a charge is not necessary, and is, I believe, in the majority of cases, entirely without foundation. A man gifted, or who imagines himself gifted, with the power of composing verses, and who has read with care and attention the great masters of the art, will insensibly reproduce many of their best thoughts. Yet such a man is not a plagiarist. He is, at the worst, only an imitator, and an unconscious imitator at that. And for this reason, if not for the one Aristotle gave, poetry may be called emphatically an "imitative art." But there is a still higher reason why one poet should become, as it were, the echo of another; and that is to be found in the nature and limitations of the human mind itself.

The maxim, *Poeta nascitur non fit*, is the true expression and interpretation of the law which governs the poetical order of intellects. At rare intervals, Nature has sent into the world a few souls endowed with the largest possible measure of ideality and poetical power. Their number may be counted upon one's ten fingers. Inspired with song, this gifted few can not choose but sing. They are the leaders of the choir; while all the rest are but subordinates, obeying the heaven-born impulse given to them by the muses' elect. As well might the mocking-bird essay the highest and sweetest notes of the nightingale, or the fledgling try the eagle's flight, as one of the non-elect aspire to reach the heavenly harmony of these natural minstrels and apostles of song. Such men as Homer, and Dante, and Shakespeare, constitute the grand natural hierarchy of genius, to which inferior minds instinctively pay homage, and before which they "pale their ineffectual fires." These are the great central lights of poetry, while all the rest are the little miniature worlds revolving around them, and really borrowing from them all their effulgence. Hence we ought not to be surprised to find nothing in the lesser luminaries which the greater do not contain. It is in the order of nature, which it were vain to attempt either to resist or reverse.

Thus the task being almost hopeless of trying to achieve any lasting distinction or success in a field already preoccupied, and incapable of further profitable cultivation, many of the most gifted intellects, in our day, are diverted from it by the greater prospect of reward held out by science, whose territory is vastly more extensive as well as prolific. It were easy to name more than one man eminent in science, whose natural gifts would qualify him to shine in the lists of poetry, and yet who has wisely chosen the path leading to higher honor and remuneration. Hugh Miller might have stood high among the Scottish bards, had he devoted himself to the muses with the same ardor and enthusiasm with which he grappled some of the profoundest ques-

tions in geology; and with how much more of justice might that line of Pope—

> How sweet an Ovid Murray was our boast!—

have been applied to Tyndall than to Lord Mansfield, had Tyndall also cultivated the muses! And yet it is safe to say that neither Hugh Miller nor Tyndall, by rivaling some of the first poets of the day, would have acquired as much honor, and, what is of far more importance, would have been of as much service to the world, as in filling so worthily and performing so honestly the respective spheres of scientific labor assigned to each of them.

Besides opening up such an avenue to men of real genius, the pursuit of science, when properly understood, is far more attractive and more in harmony with their tastes than can possibly be the cultivation of an art already touched by the hand of decay, and passing into the limbo of faded and effete systems. In the pursuit of science we go in quest of natural laws that there is every reason for believing are almost innumerable and inexhaustible; in poetry, the search is for phantoms of the imagination which, ten to one, have already flitted across other minds and been appropriated by them. In science, we search for the real, oftentimes more wonderful and beautiful than the most splendid visions; in poetry we search for the ideal, which, if it be new, now almost impossible, fails to command admiration, unless it be set before us in the most pleasing colors, and in a style of the highest finish. This elaborate toilet being unnecessary, though admissible to some extent in the treatment of scientific subjects, more range is given to the reason and less to the discursive faculties. And herein lies one of the chief advantages of the scientific method. While giving sufficient rein to the imagination to keep it in healthy exercise, it makes use of the reflective and perceptive powers in an eminent degree. Hence it engenders the greatest strength and breadth of the intellect; and it is no exaggeration to say that, if all other methods were abandoned, the study of science alone is capable of raising the mind to the loftiest possible standard of development.

Sooner or later educational institutions must take notice of this fact, and give it the heed its vast importance deserves. It seems impossible that a few narrow-minded patrons and disciples of the old system, watching at the gates, should much longer shut out from our seminaries of learning that great herald of freedom, of reform, and of progress, panoplied in the armor of truth, who has already dethroned so many idols of the forum, the pulpit, and the market-place, and who stands ready, on entering these seminaries, to perform a similar lustration. And nothing needs it more. Palsied almost by a *régime* which administers public instruction on pretty much the same plan upon which wars are conducted in some of the countries of the Old World—that is, without adopting either the new discipline or the new arms

which have enabled other countries to achieve victories—our system of public schools is sinking into decrepitude and decay for want of a new stimulus. Give it this in the shape of lessons in modern science, in all its freedom and amplitude, and it will be infused with new life. Give it this, and the education of our youth will be something more and something higher than injecting into the mind several new languages, to the sad neglect of the mother tongue, and loading the memory with a useless mass of rules, and definitions, and other abstract forms, which are forgotten as soon as the student enters upon the stage of practical life.

But to return from what may seem a digression. The influence exerted by the march of modern science upon history and historical composition is even more direct and decided than its influence upon poetry. Dealing with the actions of man either in his individual or collective capacity, even the best historians have been in the habit, until within a few years past, of regarding them as the result either of self-directed will or of special providences. Consequently their pages are filled with the marvels wrought by heroes and conquerors, particularly those who were regarded as the especial favorites of Heaven. No margin has been left in these pages for the operation of general laws, guiding and controlling human conduct. And it is only within a recent period that the theory has been formulated that the progress of society is not to be attributed to the casual disturbances made by powerful individuals, or to the ascription of supernatural means, but wholly to the force of laws working out their results without the interference of either divine or human agency. This contribution, or rather new direction to history, constituting by far its most essential feature and element, we owe to science. A few great minds, chief among whom may be mentioned Comte in France and Herbert Spencer in Great Britain, taking their stand upon the recognized principles and harmonies prevailing in the material universe, have transferred this grand conception of law and order amid apparent discordances into the sphere of human societies. Here, as well as in the material universe, the relations existing between different communities, and between the individual members of each, are relations due to the interaction of natural forces; and here, as well as in the material universe, the changes that have been wrought out by these forces are changes analogous to those we see exhibited in the consolidation of the crust of the earth, and in the genesis and growth of the solar and stellar systems—changes, that is to say, from a state of homogeneity to greater and greater complexity and apparent elaboration of detail.

Now, this evident leaning of historians, in common with almost every other class of writers, at the present day, toward the theory of evolution, is so great, and so much is expected of them on account of this theory, that if they were practically to disregard it, in writing history, they would be almost left without readers. I might go further,

and say that the tendency to connect the facts of history with the overruling operations of law is fast breaking down the barriers which separate our views of the government of the material world from those we hold concerning the affairs of man; so that it is safe to predict that the time is not far distant when, in a philosophical point of view, no very perceptible difference will be seen between the forces which control the conduct and career of nations and those which preside over the movements and revolutions of planets.

In view of this overshadowing influence, it were useless to touch upon the minor disturbances which science is producing upon history. It may almost be described as the grand motive power, which, in our day, is dragging the car of history along with it, as it drags all the rest in the train of literature. Whether they are the luxurious palace-cars, like poetry and history, furnished with all the elegance which man's inventive genius has been accumulating for centuries, and which only the richly-endowed may enter, or whether they are the plainer passenger-cars, like fiction and eloquence, filled with a group of motley characters, of greater or less pretensions and importance, and tricked out in a variety of costumes—they are all whirled along over the same road, obedient to the impulse given them by the mighty machine which stands, or rather flies, at the head of the train.

The highest aim of science is to discover the truths of nature. Literature, aspiring to something similar to this, recognizes the highest merit of literary composition in what is called its "truth to nature." In delineations of character, in descriptions of scenery, in the skillful weaving together of the component parts of a play or a novel, in the birth of sentiment, or in the happy turn given to an expression, what we most admire is the writer's adherence to certain rules or standards that have the closest conformity with what we observe in the internal or external worlds. From what we perceive in ourselves or in things around us, we derive the measure and gauge of all literary excellence. True, our own perceptions are trained and quickened by the thoughts and perceptions of others; so that what we read or hear aids us in correcting, enlarging, or refining our literary judgments. But we must be able to combine empirical tests with subjective analysis, before the intellectual process can be completed which authorizes us to determine whether any given production reaches that highest grade of excellence implied in its being "true to nature." But what, it may be asked, does this truth to nature actually consist in? Is it necessary that the author should set before us something that really exists?—something to be seen in nature, like a tree or a waterfall? Do we require of him an absolute verity? So far from this, it is only necessary that he should not shock us with anything that, at first sight, is repugnant to our tastes or feelings—anything that bears on its face the marks of falsehood or extravagance. Within these limits, a "counterfeit presentment" is as good as the original. All that the most fastidious

reader can ask in an author is a certain similitude to nature. He never looks for anything more than what is called *vraisemblance* or plausibility. What *seems* to be true satisfies him as well as what *is* true.

How opposite to this the mental discipline and research required of the scientist! No illusions or half-truths can ever satisfy *his* mind. Engaged in prolonged labors to find out the laws of natural phenomena, he counts nothing as gained so long as these remain undiscovered. One after another chimeras vanish from his mind; theories are tried, only to be discarded, if found not to fit in with facts; verifications from many opposite quarters are applied to test the value of a given hypothesis; and, if, after all, any of them are seen to be at variance with it, the hypothesis is abandoned, though it may have been cherished with all the ardor of a first and only affection.

That the semblance of truth answers the purpose of almost every kind of literature, as well as the reality, and thus places it in marked contrast with the rigid requirements of science, is further manifest from this, that we often see two propositions or apothegms, entirely repugnant to each other, equally applauded by the multitude, and maintaining a place and a good character in current literature; while of two rival theories or doctrines in science, either both are sooner or later rejected, or they become reconciled, or one is finally substantiated. Every one's reading, if at all extensive, will readily suggest illustrations of the truth of this remark. A few of these inconsistencies or contradictions in literature may not be out of place here. First, we will compare what is said by two distinguished philosophers upon the subject of anger. "To be moved by passion," says Marcus Aurelius, "is not manly, but mildness and gentleness, as they are more agreeable to human nature; so, also, are they more manly; and he who professes these qualities possesses strength, nerve, and courage—and not the man who is subject to fits of passion and discontent. For in the same degree in which a man's mind is nearer to freedom from all passion, in the same degree also is it nearer to strength. And as the sense of pain is a characteristic of weakness, so also is anger. For he who yields to pain and he who yields to anger are both wounded, and both submit." On the other hand, Bacon: "To seek to extinguish anger utterly is but a bravery of the Stoics. We have better oracles. . . . In refraining from anger, it is the best remedy to win time, and to make a man's self believe that the opportunity of his revenge is not yet come; but that he foresees a time for it, and so to still himself, in the mean time, and reserve it." Next, hear what two others of the same guild have to advise us concerning knowledge: "It is a vanity to waste our days in the blind pursuit of knowledge; it is but attending a little longer, and we shall enjoy that by instinct and infusion which we endeavor at here by labor and inquisition. It is better to sit down in a modest ignorance, and rest contented with

the natural blessings of our own reason, than buy the uncertain knowledge of this life with sweat and vexation, which death gives every fool gratis" (Sir Thomas Browne). "No way has been found for making heroism easy even for the scholar. Labor, iron labor, is for him. . . . There is so much to be done that we ought to begin quickly to bestir ourselves. This day-labor of ours, we confess, has hitherto a certain emblematic air, like the annual plowing and sowing of the Emperor of China. Let us make it an honest sweat" (Emerson). Who shall decide when doctors disagree? Once more, look at what Herbert Spencer calls the "great-man theory" in history. He and Macaulay and Buckle, on one side, are as wide apart as the poles of the earth from Carlyle and Emerson, on the other, concerning this theory. Hear Carlyle first: "We can not look, however imperfectly, upon a great man without gaining something by him. He is the living light-fountain, which it is good and pleasant to be near—the light which enlightens, which has enlightened, the darkness of the world; and this not as a kindled lamp only, but rather as a natural luminary, shining by the gift of Heaven." To the same effect, Emerson: "Literary history, and all history, is a record of the power of minorities, and of minorities of one. . . . The importance of the one person who has truth over nations who have it not is because power obeys reality and not appearance, according to quality and not quantity. How much more are men than nations! . . . So that, wherever a true man appears, everything usually reckoned great dwarfs itself. He is the only great event; and it is easy to lift him into a mythological person."

On the other side, hear Macaulay: "Those who have read history with discrimination know the fallacy of those panegyrics and invectives which represent individuals as effecting great moral and intellectual revolutions, subverting established systems, and impressing a new character on the age. The difference between one man and another is by no means so great as the superstitious crowd supposes. . . . The sun illuminates the hills while it is still below the horizon; and truth is discovered by the highest minds a little before it becomes manifest to the multitude. This is the extent of their superiority. They are the first to catch and reflect a light which, without their assistance, must, in a short time, be visible to those who lie far beneath them." And here is what Herbert Spencer offers on the same side: "The origin of the great man is natural; and, immediately he is thus recognized, he must be classed with all other phenomena in the society that gave him birth as a product of its antecedents. Along with the whole generation of which he forms a minute part, along with its institutions, language, knowledge, manners, and its multitudinous arts and appliances, he is a resultant of an enormous aggregate of causes that have been operating for ages. . . . If it be a fact that the great man may modify his nation in its structure and actions, it is also a fact that there must have been those antecedent modifications constituting

national progress before he could be evolved. Before he can make his society, his society must make him; so that all those changes, of which he is the proximate imitator, have their chief causes in the generations which gave him birth. If there is to be anything like a real explanation of these changes, it must be sought in that aggregate of conditions out of which both he and they have arisen."

And so on through the literature of all nations, from the earliest times down to the present day, it abounds in antagonism of sentiment. And when two or more authors happen to agree, others will be found who will refute their positions, and convict them of mistakes; so as almost to justify that saying of Voltaire, that "the history of human opinion is scarcely anything more than the history of human error." More than this: not only will these various disagreements be discovered among different authors, but different passages in the same author will show a similar want of harmony, and, what is a greater wonder and anomaly still, the same passage, which will not want for admirers on account of its beauty and the justice and accuracy of the sentiments it expresses, will sometimes find just as many, even though its meaning be entirely reversed. Take the commencement of one of Emerson's latest essays, called "Resources," to illustrate what I mean. I place side by side with the original affirmative propositions their negatives:

"Men are made up of potences. We are magnets in an iron globe. We have keys to all doors. We are all inventors, each sailing out on a voyage of discovery, guided each by a private chart, of which there is no duplicate," etc.	Men are made up of impotences. We are magnets in a wooden globe. We have keys to no doors. Scarcely any are inventors, sailing out on a voyage of discovery. Scarcely any are guided by a private chart, of which there is no duplicate, etc.

Or take this passage from one of Dr. Johnson's essays: "It seems to be the fate of man to seek all his consolations in futurity. The time present is seldom able to fill desire or imagination with immediate enjoyment, and we are forced to supply its deficiencies by recollection or anticipation. . . . Thus every period of life is obliged to borrow its happiness from time to come. In youth we have nothing past to entertain us, and in age we derive little from retrospect but hopeless sorrow." If there are persons to be found who will subscribe to these views, there are more who will adopt the contrary, as thus: It seems to be the fate of man to seek all his consolations in the present. The future is seldom able to fill desire or imagination with sufficient enjoyment, and hence we are forced to supply its deficiencies with that which is immediate. . . . Thus every period of life is obliged to borrow its happiness from the present moment, etc.

Now, as I have before hinted, there is no chance for such contradictions in science; or, if they ever occur, their existence, from the very nature of the pursuit, can not be of permanent duration. There is no such thing as imaginary laws controlling phenomena. Nature

abhors a fallacy or a fiction more than a vacuum; and though for a stated period the true cause of a given phenomenon may be hidden from view, owing to the imperfect means or the imperfect intelligence employed to unravel it, and thus a fictitious origin be assigned for it, yet in course of time the error is sure to be detected and the truth to be revealed. Thus it was with the astronomical system of Ptolemy. Up to the time of Copernicus the learned world as well as the illiterate were led to believe that the sun and all the rest of the heavenly bodies revolved around the earth, as the center of the entire system. Yet, as soon as the error was exploded, and the truth demonstrated, there was a universal rejection of the one and a universal recognition of the other. So, at a later period, when the true theory of ethereal undulations, as applied to light, fought its way against much opposition into popular belief, the old theory of emanations was dropped, never to be again taken up.

Nevertheless, from what has been said, it must not be inferred that what are called coincidences of thought never occur among scientists. On the contrary, these are so common as to give license for believing in the existence of a law, akin to that of evolution if not a part of it, by virtue of which, in the progress of knowledge, certain new truths dawn upon the world, receiving expression simultaneously from more than one mind. Given the age which is ripe for any discovery, and it breaks out in many different quarters of the globe at the same moment. Men seem to be watching for it, and, like a meteor glancing across the heavens, it is witnessed by several observers from many points of the compass. Take, for example, the great law of natural selection, as applicable to man's origin—it was discovered simultaneously in England by Darwin and Wallace; while in Germany, at the same time, Haeckel had promulgated a similar theory; and in France, in a preceding age, Lamarck had laid the foundation for it in the most unmistakable manner.

But it is only in this single point of occasional coincidence or identity that the leading thoughts of science take on a certain likeness with those of literature. The analogy ends with the admission that each of these thoughts may have rival paternities. Beyond this the difference becomes manifest; and it consists in this: While the utterances of different literatures may seem to be original, this is often owing to a variation in their phraseology, an examination of which will show them to be identical; and, in addition to this, there is no criterion by which their truth can be tested. But in science, while different claims may be made for originality of discovery, each truth stands out in bold relief, is distinct and well defined, and, after it has been submitted to all the various verifications of which it is susceptible, it no longer admits of any doubt and becomes a part of the common stock of human knowledge, possessing, as nearly as possible, the attributes of positive, absolute, and immutable truth.

Owing to the endless tautologies of literature, it requires little discernment to see that it must be approaching a crisis in, if not a completion of, its destiny. Traveling in the same old circle, and treating us perpetually to the same round of entertainment without change or variety, it must gradually cease to interest, and eventually die a natural death. With no new oil to fill its lamps, steeped in a kind of Stygian darkness of its own creation, one may well exclaim with Othello:

> I know not where is that Promethean heat
> That can its light relume.

And that this would have been a natural result if modern science had not come to the rescue at the right moment, and furnished its proper share of this "Promethean heat," admits of scarcely a doubt, especially in view of the fact that the most successful cultivators of letters in modern times are found resorting, for their choicest inspiration, to the new fountains thus opened to use. Notably among poets such men as Tennyson, among historians such men as Buckle, and among critics such men as Taine, have availed themselves of these helps to their genius; while by differentiating the condition of man, in some of the most important particulars, science has so wrought upon his character and destiny as to render it possible for such splendid intellects as Goethe, Dickens, and Victor Hugo to say something original of him. For, if you strip their pages of what may be called their scientific coloring, if you take away what directly or indirectly may be traced to the magic web which science has woven all through the affairs of modern life, you strip them of much of their witchery and of most of their originality.

Now, without going into particulars, we may say generally that the way in which science has wrought this great reform and revolution in literature has been by widening our survey of both man and nature. From a being of comparative insignificance, ruled by the rod of a tyrant, or made the sport of demons, and whose views of things were bounded by the narrowest horizon, she has transformed man into a being of the highest order of which we have any knowledge, having risen to it by the operation of laws that have been shaping his destiny for ages. Step by step his powers have been unfolding and the range of his vision enlarging, until he has been able to find some clew to his origin, and some interpretation of natural laws that before were a mystery to him. By the aid of what may be considered a sort of "second sight," namely, instruments of his own invention, he has been enabled to explore the remotest bounds of creation, and thus literally open to himself a new heaven and a new earth. With the telescope he has reached the most distant of planets, with the spectroscope he has discovered many of their constituent elements, and with the microscope he has penetrated into the secrets of the minutest forms of insect life. Through molecular physics and the grand modern tri-

umph of evolution, both in its relation to man and the totality of nature, he has brought near to him many of the outlying provinces of human knowledge, and poured upon them a flood of light.

To the investigation of principles has succeeded the application of useful inventions. Theories have almost invariably germinated into practical science. From the study of mathematics, physics, chemistry, and geology, industries have been developed which have made the commonest dwelling of modern times a palace and the poorest cities a miracle of magnificence, compared with those of the past.

And all of this material advancement has been attended by a corresponding diffusion of knowledge and awakening of intellectual activity, so that the merest tyro in knowledge, at the present day, surpasses in intellectual acquisitions all that the most successful scholar of Greece and Rome could boast of, even though he had mastered all the learning of antiquity. More marvelous still, the latest expression of psychological science forces upon us the conviction that the mental faculties themselves, in harmony with the results of evolution everywhere else, are brought within its grasp, that they are thus enlarged in their capacity, and made equal to the task of furnishing through the revolving ages disclosures of the almost limitless secrets of the material world, and of the agency which brought it into being.

Here then, finally, we may look for the only avenue of escape from the doom with which literature was threatened—a doom not unlike that which settled over the Empire of Dullness as painted by the poet. In that picture the whole assembled concourse of wits and critics are represented as falling into a profound slumber, while listening to the sleepy literary performances of one or two of their heroes. Nor did *they* ever rise out of this lethargy. Fortunately, the comparison ends here. For while, without doubt, the same leaden slumber was fast settling over the prostrate form of modern Literature, the mighty enchantress, modern Science, touched it at the propitious moment with her potent rod, and woke into new life its exhausted and dying energies.

OBSERVATIONS ON THE CHAMELEON.

By O. R. BACHELER, M. D.,

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HAVING recently come in possession of a family of these interesting little animals, I have found both pleasure and instruction in studying their habits. Others of the lizard tribe are not averse to, and many seem to prefer, the vicinity of men, while the chameleon always seeks the deep jungle, away from observation.

A woman from the jungle who happened to discover their haunts

has brought me at different times eight, one large and seven smaller ones, apparently of the same family. A large bird-cage keeps them securely, but they are turned out upon the grass, or placed on trees in the garden, for an hour or two daily, while a boy is employed to watch them, catch grasshoppers, and feed them. In the cool of the morning and evening they are not inclined to wander; but when the sun is hot, if they find that they are not watched, they are pretty sure to make for the largest trees, and then there must be a general turn-out of spare hands to look them up and capture them. As their quickest pace is only about five feet per minute, they are never able to get far away, unless too long neglected. There is great difficulty in finding them sometimes, even though we may know pretty nearly where they are, such is their adroitness in concealing themselves.

We have a small gardinia-tree, the top not three feet in diameter, and the foliage not dense enough to conceal one of them, and yet, after half a dozen of them had been placed upon the branches, I have looked for two or three seconds without being able to distinguish one, though on looking more intently I could see the whole without difficulty. So, to enable us to see them when they wander, we tie a bit of scarlet Berlin wool around their loins, which enables us to trace them easily. Sometimes when on the trees the scarlet wool may be seen bright in the sunshine when the little animals themselves are quite invisible.

The chameleon has been an object of curiosity the world over on account of its power to change its color, but its power to change its form is not less remarkable. Sometimes it assumes the form of a disconsolate mouse sitting mum in a corner; again, with back curved and tail erect, it resembles a crouching lion, which no doubt gave origin to its name, *chamai-leon*, or ground-lion. By inflating its sides it flattens its belly, and viewed from below takes the form of an ovate leaf. The tail is the petiole, while a white serrated line, which runs from nose to tip of tail over the belly, becomes the midrib. Still again throwing out the air, it draws in its sides, and at the same time expands itself upward and downward till it becomes as thin as a knife, and then viewed from the side it has the form of an ovate leaf without a midrib but with the serrate line of the belly and the serrated back becoming the serrated edges of a leaf. When thus expanded it also has the power to sway itself over so as to present an edge to an observer, thus greatly adding to its means of concealment.

I have studied the changes of color with much interest. In its normal state of rest it is of a light pea-green, at times blending with yellow. The least excitement, as in handling, causes a change. The groundwork remains the same, but transverse stripes appear running across the back and nearly encircling the body in a full-grown animal, numbering about thirty, and extending from head to tip of tail. These stripes occupy about the same amount of space as the groundwork, and are most susceptible to change of color. At first they become

deeply green, and if the excitement continues gradually change to black. When placed upon a tree the groundwork becomes a deep green and the stripes a deeper green or black, and so long as they remain on the trees the color does not change. The prevailing idea, that they take on the peculiar hue of the foliage among which they happen to be, is, I think, erroneous. We have placed them on the scarlet leaves of the dracæna and among the red flowers of the acacia, with no change from the prevailing green.

My largest specimen measures from nose to tip of tail fourteen inches, the body and tail being about equal—the circumference of the largest part of the body about six inches. The legs are thick and muscular. The form of the feet, so far as I am aware, has no parallel in the animal kingdom. They resemble two hands placed palm to palm and divided to the wrist. The outer palm has three minute fingers armed with sharp, curved claws, while the inner has but two. Opened to its full extent it clasps a space of about two inches. Hands and feet are much the same, except that the feet are somewhat larger and thicker. The entire body is covered with armor. This consists of oval plates placed edge to edge. There are about nine hundred to the square inch, giving on my largest specimen, by estimate, thirty-two thousand plates. The color has its seat in the armor.

The tail coils up into a ring quite close to the body, when not required for use. The feet and tail have great power of prehension. The animal will clasp a branch with either so firmly that considerable force is necessary to detach it. Giving the tail a turn round a twig they will throw the body forward and grasp another branch a foot or more away, and so move from branch to branch. At night they hang themselves up, sometimes by the tail only, or by the tail and one or more of their claws, and so sleep.

The eyes are cones about one fourth of an inch in diameter, one half projecting beyond the socket, completely covered with armor except at the point where the pupil is seen. This is about the size of the head of a large pin, set in a delicate ring of burnished gold. The eyes act independently of each other, the cones rolling freely in all directions, one often looking straight forward while the other is turned backward, giving them a most comical appearance.

The mouth is literally an open sepulchre. When opened you see a deep cavern almost down to the stomach, with no indications of a tongue. At the ramus of the lower jaw a deposit of whitish, gelatinous matter may be seen, covered with a thick, viscid mucus. On pressing upward beneath the jaws, a round, fleshy tongue is thrown up, a fourth of an inch in diameter and extending deep into the throat, the point of which is covered by the gelatinous deposit before mentioned, much like the swab on the rammer of a cannon. There are no teeth, but the edges of the jaws are serrated to serve the purpose of seizing and holding its game.

The lot of the chameleon is to live on trees and subsist on insects. Its motions are sluggish. It lies close upon a branch, assuming a form and color suitable to concealment, with its mouth wide open. Its viscid mucus serves to attract insects, and the moment they come in contact with it they are securely caught. When within two or three inches, the tongue is thrust out like a flash, the intruder is caught on the swab and drawn into the mouth. The tongue is then drawn down the throat, carrying the victim alive into the stomach. Beyond this we are not able to trace the process. We have seen grasshoppers to the number of half a dozen thus drawn in one after another.

Whether the change of color and form is voluntary or not, I have been unable to determine. From careful observation I am inclined to the opinion that it may be both voluntary and involuntary. Change of form seems to be quite under control, and change of color appears to be so at times.

Their intelligence seems to be of a very low order. After being separated they greet one another with open mouth and a hiss. They manifest no emotion, and no form of petting seems to be appreciated. Their instinct is to conceal themselves from observation, to climb to the highest available point, and to lie with open mouth waiting for their prey to come to them. The only activity they manifest is in the use of the tongue, and in this they are not excelled by any other animal.

In conclusion, we may notice some prominent marks of design and adaptation:

1. The power to change color and form affords the means of concealment.

2. The sharp claws and muscular power of feet and tail fit it for its abode on the branches of trees, often swayed and dashed about by the fierce tempest.

3. The tenacious mucus of its mouth attracts insects, while the darting tongue by the rapidity of its motion is an offset to the sluggishness of the creature's movements.

4. Its armor-plates afford a protection from other marauders, and also from the heat of the sun and the inclemencies of the weather.

5. It is the friend of man, subsisting mainly if not entirely on insects that are injurious to vegetation.

THE UNITED STATES LIFE-SAVING SERVICE.

EXTRACT FROM AN ARTICLE IN APPLETONS' "ANNUAL CYCLOPÆDIA" FOR 1878.

By W. D. O'CONNOR,
ASSISTANT SUPERINTENDENT UNITED STATES LIFE-SAVING SERVICE.

THE scheme of this service places the long chain of complete life-saving stations on the Atlantic beaches within an average distance of five miles of each other, the object being to maintain the intercommunication of patrol, and effect the speedy assembling of several crews in case of the occurrence of a wreck requiring multiplied efforts. The complete life-saving stations are generally situated just behind the beach, among the low sand-hills common to such localities. They are typically two-story houses, mainly built of tongued and grooved pine, with gable roofs, covered with cypress or cedar shingles, and strong shutters to the windows, and are securely bolted to a foundation of cedar or locust posts, sunk in trenches four feet deep. Their architecture is of the pointed order, somewhat in the chalet style, with heavy projecting eaves and a small open observatory or lookout desk, on the peak of the roof, from which spires a flag-staff. The walls of the houses are painted drab, with darker color for the door and window trimmings, and the roofs dark red. Over the door is a tablet with the inscription "U. S. LIFE-SAVING STATION." The appearance of the houses is tasty and picturesque. Their dimensions are from eighteen to twenty feet wide by forty feet long; the later houses are twenty by forty-five. Below they contain two rooms. One of these is the boat-room, about ten feet high, occupying over two thirds of the ground-floor space, or measuring about sixteen by thirty feet, and opening by a broad double-leaf door into the weather. In this are stored the boats, life-car, wreck-gun, and most of the apparatus. The other room, about eight feet high, and measuring about twelve by sixteen feet, is the general living-room of the crew. The second story contains three rooms, one for the storage of the lighter apparatus, one for the sleeping-room of the keeper, and one for that of the men; both of these furnished with cot-beds in sufficient number for the accommodation also of the occasional guests sent to the stations by shipwreck. At stations where

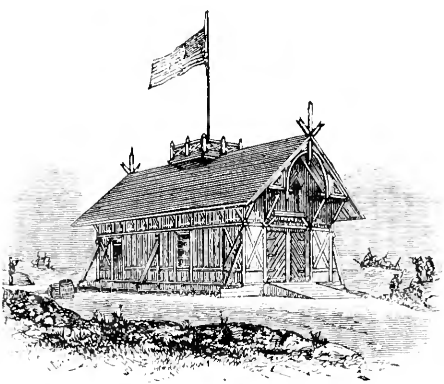


FIG. 1.—LIFE-SAVING STATION.

there is communication with the Signal Service, there is an additional room in the upper story for the accommodation of the signal officer. The later and better built stations have interior walls of lath and plaster, and are furnished outside with cisterns for the collection of rain-water. The lack of fresh water on the beaches is one of the hardships of station-life.

The life-boat stations are usually twenty-four feet high from base to peak; forty-two feet long by twenty-two feet wide, exterior measurements, and contain a loft above, and a room below twelve feet high, twenty feet wide, and forty feet long, for the accommodation of the life-boat and its gear. They are built of matched and grooved pine, with gable roofs shingled with cedar, and are painted like the other stations. They are placed on piles at the water's edge, or set on the inner side of the piers, and are furnished with an incline platform, or trap in the floor, along which the life-boat is let down and launched into the water by a windlass. Over the door of each is a tablet inscribed "U. S. LIFE-BOAT STATION."

The houses of refuge are two-story structures, of a style common at the South, with broad gabled roofs, an ample veranda eight feet wide on three sides of the structure, and large chimneys in the rear, built outside of the wall. The houses are of pine, raised about six feet from the ground on light wood posts, and the roofs shingled with cypress. Instead of glass, the windows are fitted with wire-gauze mosquito netting. The houses are about thirty-seven feet long by fifteen feet wide, not including the veranda space. The upper story is a loft, the lower has three apartments. Each house has capacity for succoring twenty-five persons, with provisions to feed that number for ten days. A boat-house is provided for each station, furnished with a galvanized iron boat with sculls.

A complete life-saving station, fully equipped, costs about $5,000; a life-boat station about $4,500; and a house of refuge about $3,000.

The stations are fully equipped with all minor appurtenances apposite to their purpose, such as anchors, grapnels, axes, shovels, boat-hooks, and wreckers' materials and implements generally; and those which are inhabited are also furnished with stoves, cot-beds, mattresses, blankets, and the utensils requisite for rude housekeeping. The crews find their own provisions. The stations are also provided with all the most approved appliances for saving life from wrecks. First among these is the six-oared surf-boat, the light weight and draught of which make it the only boat yet found suitable for service for the flat beaches and shoaling water of the Atlantic and Gulf coast. Though not invariably of the same model, it is usually of cedar, with white-oak frames, without keel, varying in dimensions, but generally from twenty-five to twenty-seven feet long, from five and one half to six feet wide, and from two feet three inches to two feet six inches in least depth. It has commonly air-cases at the ends and along the in-

terior sides under the thwarts, which make it insubmergible, and is fitted with cork fenders running along the outer sides to protect it against collision with hulls or wreckage. Its weight is from 700 to 1,000 pounds. It is guided by a long steering oar, the steersman standing in the stern. In the hands of the skilled surfmen of our coasts, it is capable of marvelous action, and few sights are more impressive than the passage out through the flashing breakers of the frail red boat, lightly swimming on the vast intumescence of the surge, held in suspension before the roaring and tumultuous comber, or darting forward as the wall of water breaks and crumbles, obedient to the oars of the impassive crew. Though sometimes thrown back and broken in desperate and unavailing efforts at a launch against a resist-

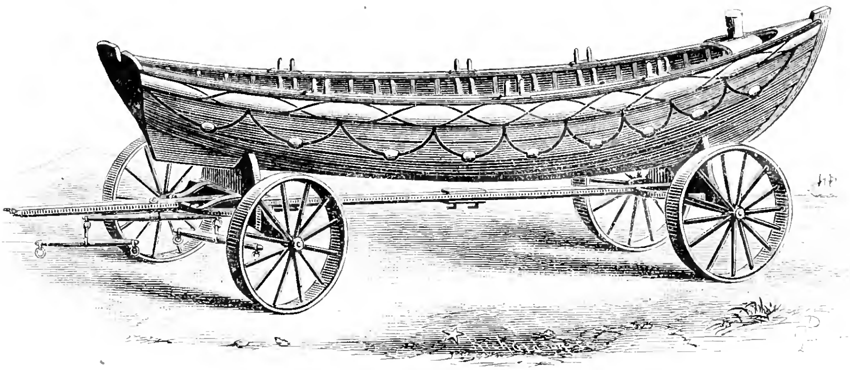


Fig. 2.—Surf-Boat upon its Carriage.

less sea, this boat, which might be upset easily, has rarely in the history of the service been capsized in passing through the surf, so great is the skill of her gallant oarsmen; and certain great surfmen, like Captain Hildreth, of Station 39, New Jersey, say that in it they will face any sea in which a life-boat can live.

On the Lakes and the Pacific coast, where steep shores or piers command deep water, and by mechanical contrivances heavy boats can be launched directly into it, the English life-boat is in general use. This wonderful contrivance, the result of a century of repeated effort, is of massive strength and stability. It is built of double diagonals of mahogany. The size generally in use in this country is about twenty-seven feet in length, a little over seven feet broad, three feet eight inches deep, carrying eight oars, double-banked, and weighing when empty 4,000 pounds. It is self-righting and self-bailing. In other words, when thrown over, which is difficult to be done, by a heavy sea, it instantly rights and empties. The first of these two extraordinary characteristics, to which a great number of advantages are sacrificed, is effected by a ponderous false keel of iron, which gives the lower part of the boat a constant determination toward the water, while an equal

determination from the water is maintained for the upper portion of the boat by a distribution of air-cases at the sides and ends, scientifically proportioned. The self-bailing characteristic is effected by a deck adjusted with reference to the draught of the boat, so that, whatever be the load of the latter, the deck is above the load-line; and, be-

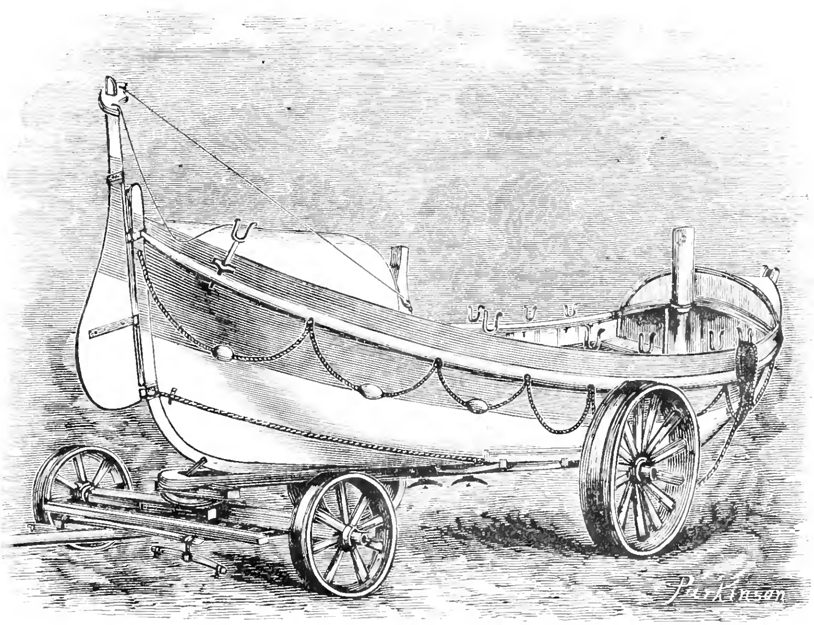
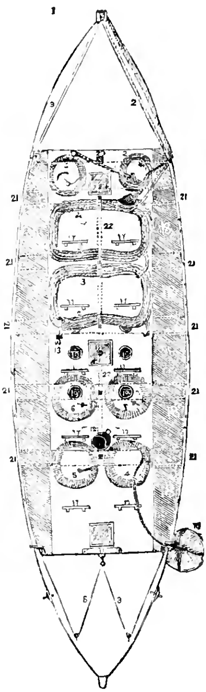


FIG. 3.—SELF-RIGHTING LIFE-BOAT UPON ITS CARRIAGE.

ing fitted with tubes extending vertically down through the bottom of the boat, it follows that whatever water the boat takes on board falls through the tubes, in obedience to the law which compels fluids to seek their level, and leaves the deck free. The delivery tubes are furnished with self-acting valves, opening to the downward pressure of the water shipped by the boat, and shutting to the pressure of the jets from below. Cork ballast adds by its weight to the stability of the boat, and augments its buoyancy in case the boat be stove. Two masts, made detachable, are provided, fitted with two low lug-sails and a jib. The boat is wellnigh invulnerable, but its great weight and draught, and the resistance its high bows offer to the wind, often make its towage by steam-tug necessary to enable it to reach a wreck at a distance. Particular attention is given to the stowage of its ropes, lines, anchors, and other articles carried in life-boats, these being arranged by a strict method with reference to economy of space and facility of use, and always kept on board, ready for service, lest any of them should be forgotten in the excitement of a sudden sum-

mons for wreck duty. Carriages of a peculiar construction are provided in England for the transportation and launching of these boats, together with skids and rollers for returning them to their carriages; but at present in this country they are let down by the trap or inclined platform directly into the water, the station being always at the water's edge. The surf-boats are provided with carriages, by which they are hauled from the stations abreast of wrecks. They are four-wheeled, with bed-pieces between each pair of wheels, on which the boat rests, and a long bar or reach connecting the front and back wheels, made separable half-way to enable the boat to be lowered to the ground by withdrawing a portion of the carriage. The American life-boat, invented by Captain J. M. Richardson, Superintendent of the First Life-saving District, five specimens of which are now in use, would seem to be better adapted for the service on our coast than the English, being considerably lighter and of less draught, and equally self-righting and self-bailing.



1. Anchor.
2. Cable.
3. Bow heaving-line or grapnel-rope and grapnel.
4. Drogue-rope.
5. Stern heaving-line.
6. } Veering-lines.
7. }
8. Jib outhaul or tack.
9. Mizzen-sheets.
10. Drogue.
11. Life-buoy.
12. Loaded cane, heaving-line, and tub.
13. Tailed block.
14. Pump-well hatch.
15. } Deck-ventilating hatches.
16. }
17. Foot-boards for rowers.
18. Side air-cases.
19. Relieving tubes and valves.
20. Samson's post.
21. Thwarts.
22. Central batten, to which the masts and boat-hooks are lashed.

Fig. 4.—Deck-Plan of Self-Righting Life-Boat, showing Manner of stowing Gear.

When boat service at a wreck is impracticable, resort is had to life-saving ordnance. The gun first in use was an *éprouvette* mortar, of cast iron, weighing 288 pounds, throwing a twenty-four-pound spherical ball with a line attached thereto, its extreme range being 421 yards. This gave place to the Parrott gun, of cast iron, with a steel tube or lining, weighing, with its ash-wood carriage, 266 pounds, car-

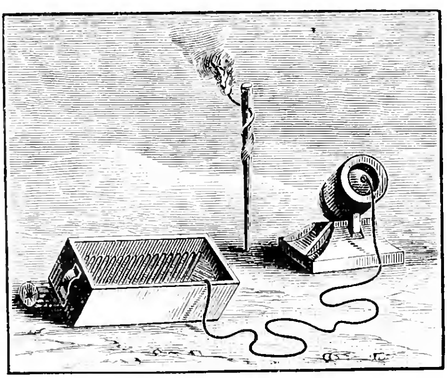


Fig. 5—Éprouvette Mortar, Faking-Box, and Match-Stave.

rying a twenty-four-pound elongated projectile, with a maximum range of 473 yards. The Lyle gun, which has superseded these, is of bronze, smooth bore, weighing 185 pounds, with a cylindrical line-carrying shot weighing seventeen pounds, and a range of 695 yards. The reduction in weight over the lightest previous ordnance is 110 pounds, and the increase in range over the old *éprouvette* is 274 yards. Other advantages of the Lyle gun are its strength, owing to the tenacity and ductility of its material, its freedom from corrosion, and its exemption from the erosive action of gases, there being little windage, and from wear by the projectile, this being nearly the length of the bore. The projectile has a shank protruding four inches from the muzzle of the gun, to an eye in which the line is tied—a device which prevents the line from being burned off by the ignited gases in firing. The shot-line is made of unbleached linen thread, very closely and smoothly braided, is waterproofed, and has great elasticity, which tends to insure it against breaking. The lines in use are of varying thicknesses, according to circumstances, ranging from one eighth to three eighths of an inch, and their length varies from 500 to 700 yards. The shot-line is carried in a faking-box —a wooden chest with handles for convenience in carrying. There are two or three sizes in use, the dimensions of the largest being about three feet long by one and a half wide, and a foot deep. Connected with it is a frame, a little larger than the box, with a row of wooden pins set vertically into its four sides. A false bottom, which is a tablet of wood pierced with holes corresponding to the pins, is let down over them until it reaches their bases, and rests upon the frame. In disposing the shot-line, the faker begins at the corner, and coils it in successive diagonal loops or fakes over the pins, layer above layer, until the line is completely rove. The box is then let down over the pins, and fastened at each end to the frame. It is now ready for transportation to the scene of a wreck. When brought there, it is turned upside down, disclosing the false bottom, with the frame superimposed upon it. Two men, one at each end of the box, release the fastenings, and, each pressing his foot upon

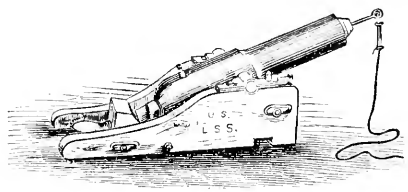


Fig. 6.—Lyle Gun.

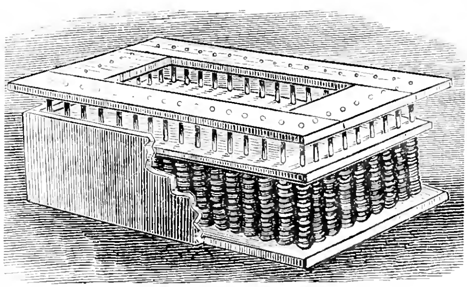


Fig. 7—Method of withdrawing Frame and Pins from Shot-Line in Faking-Box.

the false bottom to keep it down, the two lift off the frame, bringing away the pins with it. The false bottom is then lifted off the line, which remains in the box, disposed in the layers of diagonal loops or fakes made by the pins. The line is thus arranged to pay out freely, and fly to a wreck without entanglement or friction. The end is now tied into the eye of the shank of the shot in the gun; the box, which is always placed a few feet to the windward of the gun, is canted up on one side at an angle of about forty-five degrees; and the line is ready for firing. The line is always brought ready faked to the scene of action and fired from the box. In case a second shot is necessary, the line is laid out in large loops upon a tarpaulin spread out upon the beach, which is called French faking. This is done to save time,

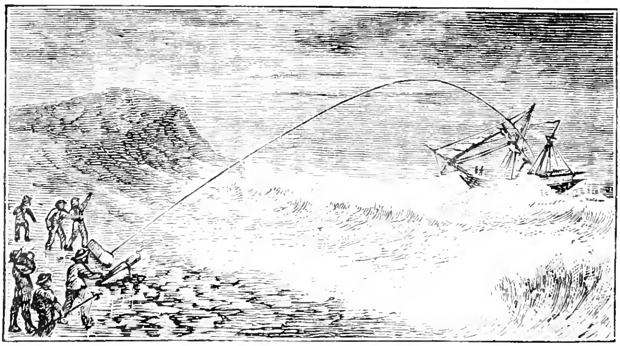


Fig. 8.—Firing Shot-Line to Wreck.

twenty-five or thirty minutes being requisite to fake a line properly in the box; but it is less desirable, as exposure to the flying sand or the rain or spray lessens the range by impeding the flight of the line. When the shot-line reaches the wreck, the shore end is connected with the whip or hauling line. This is an endless rope or ellipse, an inch and a half in circumference, and long enough to reach from the shore to the vessel. It is reeved through a pulley-block, having attached to it to several feet of rope called a tail. The shot-line is tied around both parts of the whip, a few feet above the pulley-block, and the crew of the vessel at a signal haul the whip on board by means of the shot-line. With it goes a tablet called a tally-board, on which are printed, in French upon one side and in English upon the other, directions for properly setting up the whip-line on the vessel. When this is done, a signal is made to the shore, and a hawser of sufficient length and four inches in circumference, to which is attached another tally-board, bearing printed directions in English and French for its disposition, is tied to one part of the whip or hauling line, and is sent out to the vessel by the life-saving crew pulling upon the other part. Obeying the directions of this tally-board, the men on the ship fasten the hawser to the mast about eighteen inches above the hauling-line. A crotch,

made of two pieces of wood, three by two inches thick and ten feet long, crossed near the top, so as to form a sort of X, and bolted together, is erected, and the shore end of the hawser is drawn over the intersection. A sand-anchor, composed of two pieces of hard wood, six feet long, eight inches wide, and two inches thick, crossed at their centers, bolted together, and furnished at the center with a stout iron ring, is laid obliquely in a trench dug behind the crotch. An iron hook, from which runs a strap of rope, having at its other end an iron ring called a bull's-eye, is now fastened into the ring of the sand-anchor. This strap connects by the bull's-eye with a double pulley-block at the end of the hawser behind the crotch, by which the hawser is drawn and kept taut. The trench is solidly filled in, and the imbedded sand-anchor, held by the lateral strain against the side of the trench, sustains the slender bridge of rope constituted by the hawser.

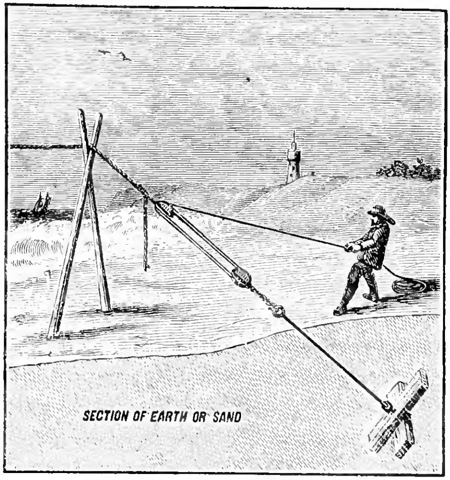


Fig. 9.—Crotch, Hawser, and Sand-Anchor.

If there are a large number of persons to be saved, the life-car is used. This is a covered boat of galvanized sheet-iron, eleven feet four inches long, four feet eight inches wide, and three feet deep, weighing 225 pounds, which will hold six or seven persons. It is covered with a hatch, and has a few perforations made in the top from the inside, which admit air, while their raised edges exclude water. It is suspended on the hawser by bails and rings, to which are also attached the hauling-lines, all these ropes being arranged to it before the hawser is fastened behind the crotch. It is evident that, by pulling on one part of the hauling-line, the life-saving crew can send out the suspended life-car to the vessel above the surface of the sea, and, when it has received its load, draw it back to the shore by pulling on the other part. Its use has been uniformly successful, 201 persons having been saved by it from the immigrant ship Ayrshire at its first

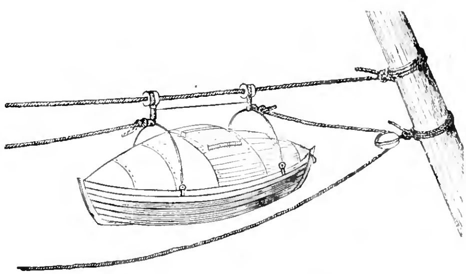


Fig. 10.—Life-Car, with Hawser and Hauling-Lines.

trial, in a sea which made boat service impossible and which utterly destroyed the vessel. Another mode of using the life-car is the following: By means of the shot-line, a single hauling-line, something more than the length of the distance of the wreck from the shore, is drawn on board, the end of it being made fast to a ring at one extremity of the life-car. To a ring at the other extremity a similar hauling-line is attached, the end of which remains on shore. By the first hauling-line the car is dragged out through the water, as a boat, by those on board, and, having received its load, is dragged back again through the water by the line handled by the men on land. This method of working the life-car is resorted to under certain exigencies, but is less desirable than the other, because, although the people it contains are safe, the car is liable to be turned over and over in its passage through the breakers, much to their discomfort.

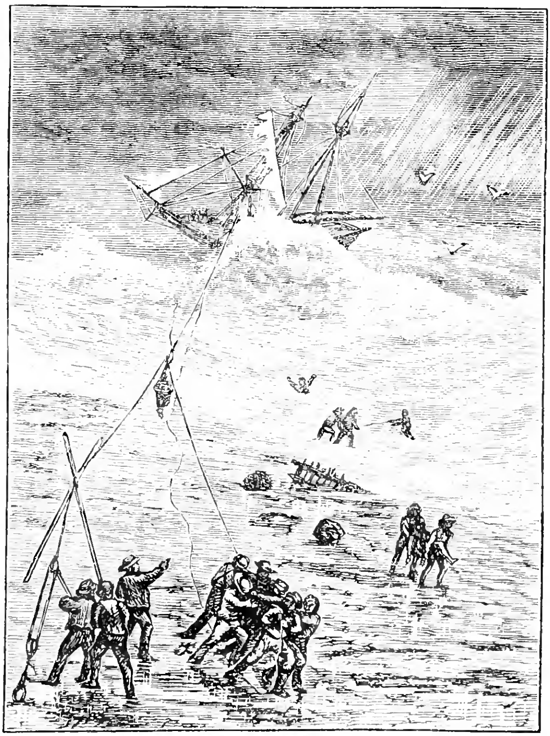


Fig. 11.—Rescue by Breeches-Buoy.

The large majority of the vessels now stranded upon our coasts being coasters (schooners and barks), with crews of from six to ten men, the breeches-buoy is more commonly used. This is a much lighter contrivance, and therefore easier to transport and handle, weighing only twenty-one pounds, and requiring for its use less heavy

cordage, the difference in weight between the two with their appendages amounting to over 500 pounds. It consists of a common circular life-preserver of cork, seven and a half feet in circumference, to which short canvas breeches are attached. Four rope lanyards fastened to this circle of cork meet above in an iron ring, which is attached by a strap around a block, with composition sheaves, and is

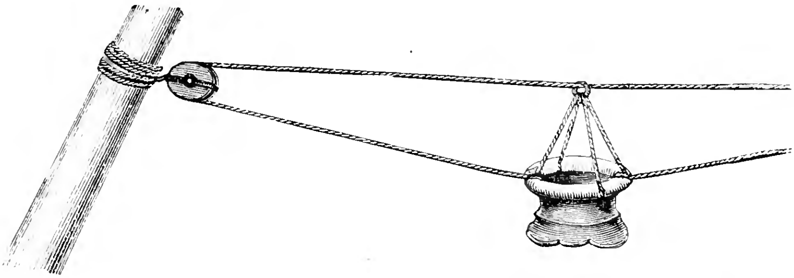


FIG. 12.—USING THE BREECHES-BUOY WITH HAULING-LINE WITHOUT HAWSER AND TRAVELING BLOCK.

called a traveler. The hawser passes through this block, and the suspended breeches-buoy is drawn between ship and shore by hauling-lines, like the life-car. At each trip it receives but one person, who gets into it, sitting, holding to the lanyards, sustained by the canvas saddle, with his legs dangling below, and is pulled swiftly ashore. When there is imminent danger of the breaking up of the vessel, and great haste is required for the rescue, the hawser is sometimes dispensed with, one part of the hauling-line being used for the buoy to travel upon.

The apparatus having to be drawn by the men where horses are not accessible, a hand-cart is provided for this purpose, strongly built, with large wheels having five-inch tires to keep them as much as possible from sinking into the sand. The surf-boat is dragged in the same way on its carriage.

A medicine-chest is furnished for each station. It contains wine and brandy, mustard plasters, volatile salts, probangs, and a few other simple remedies and appliances for reviving exhausted persons or aiding to restore those apparently drowned, printed directions for the use of which are pasted within the lid of each chest. A method of resuscitation is published in the regulations of the service, which is also practically taught to every member of the crews by the visiting surgeon. The method is that of Dr. Benjamin Howard, of New York, with certain modifications by Dr. John M. Woodworth, late Supervising Surgeon-General of the U. S. Marine Hospital Service. Its extreme simplicity of application and great general utility merit for it a particular description. It begins with the attempt to arouse the patient, who must not be removed, unless there is danger of his freezing, but his face exposed to the fresh air, the mouth and nostrils wiped

dry, the clothing quickly ripped open so as to expose the chest and waist, and two or three quick, smarting slaps given upon the stomach and chest with the open hand. If the patient does not at once revive, a bit of wood or a cork is placed between his teeth to keep the mouth open, he is turned upon his face, a large bundle of tightly rolled clothing is placed beneath the stomach, and the operator presses heavily upon his back over the bundle for half a minute, or as long as fluid

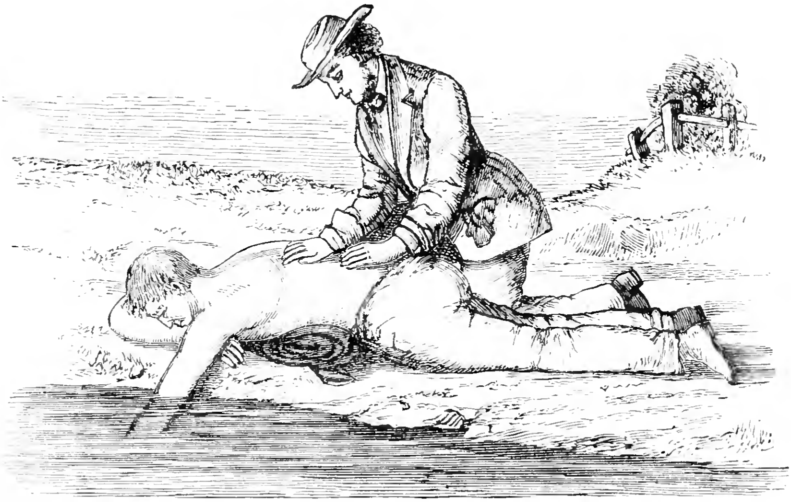


Fig. 13.—The First Step taken, by which the Chest is emptied of Air, and the Ejection of Fluids is assisted.

flows freely from his mouth. (See Fig. 13.) The mouth and throat are then cleared of mucus by introducing into the throat the end of a handkerchief wrapped closely around the forefinger; the patient is turned upon his back, under which the roll of clothing is placed so as to raise the pit of the stomach above the level of any other part of the body. If an assistant is present, he holds the tip of the patient's tongue, with a piece of dry cloth, out of one corner of the mouth, which prevents the tongue from falling back and choking the entrance to the windpipe, and with his other hand grasps the patient's wrists and keeps the arms stretched back over the head, which increases the prominence of the ribs and tends to enlarge the chest. The operator then kneels astride the patient's hips and presses both hands below the pit of the stomach, with the balls of the thumb resting on each side of it and the fingers between the short ribs, so as to get a good grasp of the waist. (See Fig. 14.) He then throws his weight forward on his hands, squeezing the waist between them with a strong pressure, counts slowly one, two, three, and, with a final push, lets go, which springs him back to his first kneeling position. This operation, which converts the chest of the patient into a bellows, is continued at a rate

gradually increased from four to fifteen times in a minute, and with the regularity observable in the natural motions of breathing which are thus imitated. If natural breathing is not restored in three or four minutes, the patient is turned a second time upon the stomach in an opposite direction from that in which he was first turned, the object being to free the air-passages from any remaining water. The artificial

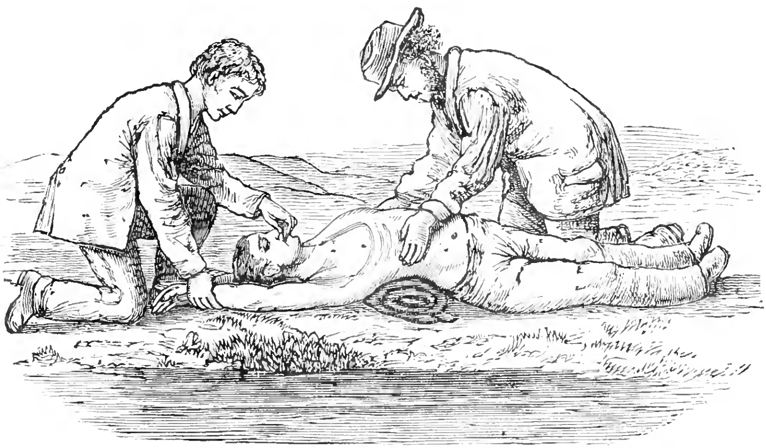


FIG. 14.—THE POSITION AND ACTION OF THE OPERATOR IN PRODUCING ARTIFICIAL RESPIRATION.

respiration is then resumed and continued if necessary from one to four hours, or until the patient breathes, and when life appears the first short gasps are carefully aided by the same method. From the first, if assistants are present, the limbs of the patient are rubbed, always in an upward direction toward the body and with firmness and energy, the bare hands being used, or dry flannels or handkerchiefs, and the friction kept up under blankets, or over dry clothing. The warmth of the body is also promoted whenever possible by the application of hot flannels to the stomach and armpits, and bottles or bladders of hot water, or heated bricks, to the limbs and the soles of the feet. As soon as breathing is established, the patient is stripped of all wet clothing, wrapped in blankets only, put to bed comfortably warm, but with a free circulation of fresh air, and left to perfect rest. For the first hour a little hot brandy-and-water, or other stimulant, is given every ten or fifteen minutes, and as often afterward as may be expedient. After reaction is established the patient is in great danger of congestion of the lungs, and unless perfect rest is maintained for at least forty-eight hours he may be seized with difficulty of breathing, and death ensue if immediate relief is not afforded. In such cases a large mustard plaster is placed upon his chest, and, if he gasps for breath before the mustard takes effect, his breathing is assisted by the careful repetition of the artificial respiration. In connection with this process the surfmen are

instructed to consider the clinching of the jaws and semi-contraction of the fingers, which have been considered signs of death, to be on the contrary evidences of vitality, and to borrow from them hope and confidence for redoubled effort in the work of resuscitation. This is a discovery of Dr. Labordette, of the Hospital of Lisieux, in France. He found by numerous experiments that the jaws and hands relax when death ensues, *rigor mortis* supervening later.

The Merriman life-saving suit is supplied to the stations, and often proves useful by enabling surfmen to effect rescues of individuals struggling in the breakers, and even to reach wrecks and assist benumbed crews to set up the life-lines. It consists of footed pantaloons of India-rubber, and above the waist of a double ply of the same material covering all but the face, and inflated severally in breast, back, and head, between the plies, by three rubber tubes. Being thus buoyant, and also impervious to air, its wearer can neither drown nor freeze. Since its original introduction at the stations, the exploits of Paul Boyton have given it celebrity.

Upon occasions of boat-service, the life-saving crews are required by regulation to wear the cork life-belts devised by Captain Ward, the Inspector of the Royal National Life-Boat Institution of Great Britain. These life-belts weigh severally only four and a half pounds;

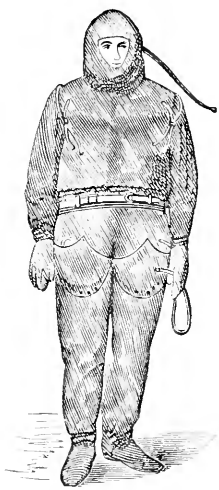


Fig. 15.—Life-saving Dress.

Fig. 16.—Cork Life-Belt.

are flexible, being composed of a series of small blocks of cork strung together; have crenellations under the arms, leaving those members unimpeded in action; and, by rendering the surfmen secure from drowning, double their efficiency to assist others in case of exigency.

The stations are opened for service on the seaboard from September 1st to May 1st, or for a shorter period wherever deemed prudent,

and on the Lakes from the opening to the close of navigation. Strict watch and ward is maintained during this period—at the life-boat stations by lookout, and at the complete life-saving stations by patrol. The period between sunset and dawn is divided into watches, each kept by two men of the crew of six at the several stations. In conformity with this routine, two men issue at sunset from each coast station. They carry beach lanterns and are provided with Coston signals, which are cylindrical cases of combustible materials, fitted into percussion holders. One man goes to the right, the other to the left, each continuing along the beach, keeping watch to seaward, until he meets a similar patrolman from the next station, when he returns to the starting-point, where he sets out again, keeping up his march until the term of his watch expires and that of the next patrol begins. Thus, every night, along the ocean beaches, in moonlight, starlight, thick darkness, driving tempest, wind, rain, snow, or hail, a file of sentinels is strung out, steadily marching, on the lookout for endangered vessels. The duty is arduous, often terrible. Storm tides flooding the beach, quicksands, the bewildering snowfall, overwhelming blasts, bitter cold, are often conditions to the journey. The result is that, should a vessel strand, which usually takes place on some shoal or bar at from one to four hundred yards' distance from the beach, instead of being left unnoticed for many hours, to be torn to pieces by the furious surf, she is sure to be soon discovered by the patrolman. Seeing her, he at once strikes the bottom of his percussion holder, driving its spike into the Coston cartridge, which ignites with a fierce deflagration, reddening the darkness, and notifying those on board the wreck that they are seen. The patrolman then races to his station and brings the crew. The keeper knows by the state of the surf whether the boat can be used, or whether to resort to the life-car, or breeches-buoy. The boat always puts out if possible, this being the speediest mode of succor. If the surf be impassable, the wreck-gun casts its lariat over the wreck, the hawser and hauling-lines are set up, and the imperiled seafarers are drawn ashore. By whatever mode the rescue is effected, it involves hours of racking labor, protracted exposure to the roughest weather, and a mental and bodily strain under the spur of exigency and the curb of discipline which greatly exhausts the life-saving crews. In the case of the boat-service, whether by surf-boat or life-boat, tremendous perils are added to new hardships. The result of these gallant toils in the rigors of the winter beach and the drench of the surf, since the date of original organization in 1871, has been extraordinary. During this period of eight years statistics show that there have been, within the scope of life-saving operations, 6,287 persons imperiled on stranded vessels. Of these, 5,981 were saved, and only 306 lost—197 of these at wrecks remote from stations, or at times when they were closed, and the others, in nearly every instance, under circumstances which rendered human aid impossible. During this period the sta-

tions have also given succor to 1,382 persons. Their crews have, moreover, notably performed wreckers' duty, and saved large amounts of marine property. The virtue of organization is attested by these results, but large credit must always be given to the noble fidelity, capability, and dauntless courage of the stout groups of seven who man the lonely stations. Wherever native manliness is held in honor, these heroic Pleiads of the seaboard beaches, and the gangs of nine who drive the life-boats through overwhelming seas upon the Lakes and the Pacific, with hearts greater than danger, can never fail of their meed.

DISEASED CONDITION OF THE FACULTY OF WONDER.

By Professor GAIRDNER,

OF THE UNIVERSITY OF EDINBURGH.*

I HAVE never gone into this matter professionally, or even as a scientific man, but have always on the other hand held that the duty of a physician toward these things was to have as little as possible to do with them. But, still, in my career instances have come to my knowledge, and it was in consideration of all these that I was led to attempt to formulate a few nights ago the state of my mind upon the subject by saying—and it is something like a distinct, and I think not an untrue and unintelligible definition—that I call the state of mind of people inclined to spiritualism *a diseased condition of the faculty of wonder*. I hold that the faculty of wonder, or reverence, if you like to call it so, is an innate and necessary part of the human mind. Nay, more, it is one of the most essential, one of the most beneficial of all our endowments—that faculty by which we grasp, by which we strive to a certain extent to comprehend, and, if we do not comprehend, submit ourselves to, and even delight in the unknown—by which we strive to apprehend that which we can not comprehend. You will easily see that the higher aspect of this faculty of wonder is the basis of the whole of our religious aspirations. Therefore it can not be that I mean to denounce it—to speak ill of it. But, like all our other faculties, this part of our mental constitution is liable to abnormal action—in fact, to get into a state of disease. What I said of this faculty is, that, when it is rightly applied by a thoroughly healthy mind to the connection between the spiritual and the material world, it does or should find abundant opportunity for its exercise within the realms of strict law. I do not mean here to touch or raise the question whether there are what are called miracles connected with

* Extract from a lecture to his class, on the subject of spiritualism.

the spiritual world any more than in the physical world. That is beside my argument. My argument at present is simply this, that within the realm of law, clearly understood as such, there is food for the faculty of wonder in all its legitimate aspirations far more enduring, far greater, and far grander than anything that can be developed in the way of those communications of table-turning, table-rapping, or anything of that kind. And the instance I gave was just one out of endless instances—to try and conceive of the manner in which the spirit of man, that which he knows to exist, and, in fact, to be himself—his *ego*—communicates through his nerves with his muscles—how it is capable of being so minutely directed that along the lines of nervous communication it will arrive at a particular muscle or particular group of muscles, and perform all the complicated muscular acts which we know to be the physical and tangible results of the manifestations of our spirit. In other words, the most commonplace appearance of a spirit that you can name—the most every-day manifestation in the world, and that which we are most certain of in our own consciousness—is, when you come to think of it, an absolute and perfect mystery, which only becomes comprehensible to us because we know it to be a fact, and because it lies within the divine order of things. It is physiological. What spiritism or spiritualism appears to require of us is, that having got our every-day consciousness of this matter for wonder—having got all this marvelous adaptation of spirit to matter—having a set of thoroughly organized and thoroughly known channels by which the spiritual world is revealed in the material, and by which the Great and Supreme Spirit is enabled to reveal himself to every one of us—having, I say, got the absolute proof and evidence in our own souls and our own bodies of a set of laws appertaining to this matter, what spiritualism requires of us to do is to cast aside the whole of these laws, and to admit a set of interferences, not exceptional, not for grand and very, very exceptional objects, but a set of every-day constant interferences with the law of the action of spirit and matter—as such, known to all of us—interferences which are not only not in accordance with that law, but which are absolutely subversive of the ordinary results of that law. Just let us suppose this: Suppose it proved, once for all, that the spirit of a departed person—a disembodied spirit, a spirit that is wandering in space, a spirit which is not limited by the conditions of material investment—has the power to appear to you, and to reveal to you what is being done or written, or has been done by some friend of yours on the other side of the globe, or who has passed beyond the grave, and that it has had access to documents no mortal could have seen, what appears to be the necessary consequence of this doctrine? This, among others, that no scrap of writing—that no single act that a man does could be concealed, or at least could be perfectly sure of being concealed, from his neighbor—from any man who may have the greatest possible interest in know-

ing it, perhaps for a nefarious purpose. You write a document of the most private character; you shut it up in a locked drawer; it affects the character of many persons; it would be treason to morality to publish that document in the newspapers. There is nothing to hinder, so far as we know the laws of this newly invented spirit world*—there is nothing to hinder any disembodied spirits who are about from getting access to the paper, and having it published in the newspapers. But here I say on the other hand—and this is the result of experience—it has been shown that this can not be done.

Having alluded to the incident of a £100 note being left in a sealed envelope in the Bank of England, the owner having promised to give it up to any spiritualist who could tell the number, but for which no application was received, Professor Gairdner proceeded: It was in some way or other impossible, apparently, for the spirits, greater or less, although it was asserted that they were able to reveal the secrets of one man's heart to another, to read the number of that note in these circumstances. I say that it was not only in fact impossible, but I say this, that, had it in fact been possible, it would have shown a state of matters which, humanly speaking, would have been subversive of the divine order. It would have entirely destroyed that system of law by which we know that, in a way which is absolutely wonderful and absolutely inscrutable, spirit does communicate with matter, as we know, every day of our lives in this world. The state of mind of the persons who come prepared to believe these things—who come to the investigation of them with previously established ideas, who regard doubt or hesitation as I would say, a sin, but let us rather say an error, and a sure way of keeping manifestations back, while open-mouthed credulity is the only frame of mind in which to come to the investigation; the state of mind of such persons—who, I believe, may be numbered in thousands, and possibly in millions, in this country and in America—is, to my idea, a diseased state of mind. I admit fully that many of these persons are apparently able to conduct their own affairs. I freely admit that many of them are very moral and well-intentioned persons. I am equally inclined to believe that this Mr. Allan Kardec, within certain limits which I can not attempt to define, was a truthful man. But that does not hinder me from believing that there is disease at the bottom of these things, and it is a disease of the faculty of wonder, by which that faculty, intended for the noblest purposes in the organization of the human mind, is perverted to some of the lowest of all purposes, and even to the abetting

* The preceding portion of the lecture shows by extracts from the works of spiritualists, and especially of Allan Kardec, that according to these authorities lying, mischievous, and impish spirits everywhere abound, and are permitted to play their pranks freely for the delusion of those who are willing to be deluded; whereby the thorough going spiritualist finds no difficulty in explaining, according to his theory, proved instances of absurdity or imposture.

of trickery. One other thing I had on my lips to say the other night, but I did not say it then, and I am not quite sure that I should do so now ; therefore I can only indicate it very slightly. It is that this conclusion as to the diseased nature of these manifestations, so far as the mind of the recipient is concerned, was impressed upon me at a very early period during the epidemic of manifestations—of electro-biology as it was called then—in 1851 in Edinburgh. I had a dear friend, since dead, and dead under circumstances that no injury to him or any one else can be brought about by telling the story. He was of a bad constitution originally. He had entered on the study of medicine, and with such ardor had he taken up the branch of physiology that I regarded him as likely to be one of the greatest physiological inquirers of the day. I had not only respect for him as one of my pupils, but I had for him a feeling of regard and love. He was drawn into the vortex of Dr. Gregory's drawing-room exhibitions, and his case appears in Dr. Gregory's book ; I knew it was disease ; I felt it was disease. He was made to go out of himself ; he was made to wander here, there, and everywhere ; he was made to converse with all the philosophers of ancient Greece—with Aristotle, with Socrates, and with Plato, and to tell what they said to him. He then took a somewhat serious illness, and I became his medical attendant, and for a time he was under my care alone. The persons who had obtained this strange influence over him still kept coming about him, but at last I had to forbid their presence. He got over his illness, and became so far better, and they then again attempted to catch him, but failed. Their power had gone, or almost gone, and only the poorer class of manifestations could be produced, and ultimately none of them could be produced, and for a considerable time after that he continued in better health. But the essentially diseased character of the whole thing was plain from this, that within a year or two he showed manifestations of actual insanity. The poor fellow excited my sympathy, and I made an effort to save him. I took him to London, got him to apply himself to histology, and tried to excite all his better and scientific predilections. But the morbid tendency was too strong, and ultimately he ended his days within the walls of an asylum. I do not mean to say that Dr. Gregory made him mad. That would be wrong. I do not think that was so, because he was better for a good while after that, but I mean to say that the tendency of these things in a constitution hereditarily predisposed to insanity is to insanity, or as Shakespeare has put it in the mouth of King Lear, when conscious that he is himself upon the giddy verge, "That way madness lies."

ARE EXPLOSIONS IN COAL MINES PREVENTABLE?

By FRANCIS R. CONDER, C. E.

THE heaviest tax that can be imposed upon a nation is one that is paid in human lives. From whatever point of view the subject may be regarded, this conclusion is irresistible. If we look at it according to purely economical considerations, we may obtain very remarkable results. It has been estimated that an actual money cost of £300 is incurred in raising a boy, cradled among the poorest classes, from birth to manhood. It does not require us to ascend very high in the social scale before we find that this estimate must be trebled. If we take what we may call the cost price of the human unit at any definite time, say at £500 on arriving at maturity, the producing power of the unit in question will bear some relation to that sum; the more costly and careful education producing, as a rule, the more valuable result, as to productive power. If the laborer who earns 14*s.* or 15*s.* a week adds £50 per annum to the wealth of the country, the physician, the scientific military or naval officer, the barrister, or the engineer, may look forward to the time when his yearly labor will be worth more than a hundred times that amount, even if appraised only by the price he is actually paid for his time. Taking any producing individual, whether valued at £50 or at £5,000 per annum, at any period of his career, no income tax to which he can be subjected can approach in its pressure the extravagant tax of death. For the payment of that tax at once annihilates the total earning power of which there was, until that moment, a fair mathematical expectation.

The tax upon human life which is caused by war is one as to which philosophers and philanthropists have long written, and as to which generation after generation has complacently declared its own advance on its barbarous ancestors; although generation after generation has too often seen increasing holocausts offered on the altar of battle, with continually less and less excuse—the word justification it is too often but a mockery to use. We have seen, not so very long ago, that peace has its death tax as well as war. And we wish to call attention to a tax of this nature which, as far back as statistics have been collected, appears to be paid in this country with a grim and appalling regularity.

Regularity, that is to say, when viewed in the light of statistical returns. From any other point of view the deaths of which we speak occur with the most frightful and unexpected caprice. There may be a period of months during which none of the calamities which quietly occur are brought under public notice. Then there may be a terrific telegram, and an announcement in the largest letters used by the daily press, "Frightful calamity at a coal mine—sixty lives lost!" Again,

at another time, three or four minor calamities occur on the same day, at different spots; or within a few hours or days of one another. The public is, no doubt, deeply moved by these announcements. Free and charitable aid never fails to be forthcoming for the widowed and orphaned survivors of a colliery massacre. The question is ever newly raised, "Can nothing be done to prevent these terrible disasters?" Legislators try their hands at prevention. Men of science try their hands at prevention. It is pointed out authoritatively that much of the loss of life thus occurring is preventable loss. Robert Stephenson, when admittedly standing at the head of his profession, being himself a large colliery owner, and having for several years of his life had to descend a coal-pit at 4 A. M. daily, to visit all the workings of the mine, declared that there was hardly a colliery in England that might not be worked with perfect safety from explosions; and pointed out that the great means for insuring safety was to quadruple the shaft area in every colliery. And yet the slaughter goes on! In 1864 it was at its minimum. Only 857 lives destroyed in coal mines are reported for that year, being at the rate of a human life for every 110,000 tons of coal raised. In 1866 it attained its maximum, the lives lost amounting to 1,484, or one for every 68,000 tons of coal. From 1861 to 1875 inclusive, 15,908 lives were lost in raising 1,608,576,193 tons of coal, being very nearly a thousand deaths in each year. Roughly speaking, the life tax is at the rate of a life per 100,000 tons of coal.

The comparison of the number of men employed, of tons of coal raised, and of lives lost, year by year does not appear to throw much light on the subject. Such a comparison, indeed, shows a steady decline in the industrial and productive power of the colliers. But no relation is discernible between the out-put per man, taken as indicating either the number of hours worked on the average, or the industry exerted in these hours, and the death rate. From 1861 to 1866 occurred a steady increase in the productive power, not only of the collieries of Great Britain, but of the individual colliers. In 1861 the total yield of 86,039,211 tons of coal was produced by 282,473 men, being at the rate of 305 tons of coal per man. In 1866 the yield had risen to 315 tons per man, and in 1870 to 321 tons per man. From this year the productive power of the miners has decreased, although that of the collieries has continued to advance. In 1874 each miner only raised 249 tons of coal. In 1875, 133,306,486 tons of coal were raised by 525,843 men, being at the rate of 253 tons apiece. Thirty years previously, in 1845, the number of tons of coal raised in the year was 31,500,000. An increase to a fourfold amount, when the figures attained are so large, is probably without a parallel in productive industry. In 1840 about 700 collier vessels were employed in the London trade. Their average cargoes were 220 tons. In 1876 the fuel shipped to foreign countries amounted to 16,299,077 tons, and that sent coastwise to 11,015,178 tons.

At the time when the details of the coastwise coal trade were discussed by the Institution of Civil Engineers, in the presence of Mr. Robert Stephenson, in 1855, so little was it anticipated that railway conveyance would compete with the sea-borne traffic in coal for long distances, that the possibility was not even suggested in the debate. The Great Northern Railway was then open to Doncaster, and the coals conveyed over the line were enough to make the gross weight passed over the up lines as 1·74 to 1, the cost of maintenance being as 1·98 to 1. Mr. Carr observed that more damage was done to the permanent way, as might be supposed, by the extreme loads of the coal trains than by ordinary goods and passenger trains, and said that "this would account for the deterioration increasing more rapidly than the tonnage." Mr. Stephenson stated that the wear and tear of the way was proportionate to the number of pairs of wheels that ran over it, and to the weight on those wheels; and declared on another occasion that he could not, as a man of honor, be a party to the carrying of his own Clay Cross coals on the London and Northwestern Railway, at the freight of one halfpenny per ton per mile, as such a rate was injurious to the railway company.

To return to the casualties of the coal mines. The most terrific form of destruction, that of explosion, is not the most fatal, numerically regarded. Taking an average of fifteen years, twenty per cent. of the fatal casualties were attributable to explosions, thirty-three per cent. to falls of coal and of roof, fifteen per cent. to shaft accidents, and the rest to miscellaneous causes. Thus of the tax of ten lives per million tons of coals, the fifth part, or two lives per million tons, may be regarded as deaths that are certainly preventable by the due enforcement of those provisions which the mining engineer decides to be proper. In the years 1867–'69 the mortality from explosions amounted to twenty-nine per cent. of the whole. The general average for those years shows a death rate of one life per 84,000 tons of coal; so that we may regard the effect of the precautionary measures taken by the Legislature as having effected a saving of about a third of the number of human lives that would otherwise have fallen victims to explosions.

The question not unnaturally arises, What is the real cause that leads the miner to affront a peril of this frightful magnitude? It is all very well to speak of recklessness of life, of objection to innovation, of ignorance of scientific principles, and the like, but those who are most familiar with the working classes will be the least disposed to admit that the true knot of the question can thus be cut. It requires no instruction in chemistry for the miner to be made acquainted with the fact that the vapor (if we must not use the word gas) that he sees burning brightly as it issues from the coals in his kitchen fire is apt to issue from the face of certain coal mines, and that it will take fire in the mine as readily as in the grate. He may not be, and probably is

not, aware that this fire-damp is composed of about one third hydrogen and two thirds carbon. He may be ignorant that the proportions of admixture of fire-damp with ordinary air which are such as to cause explosion are, when the former is more than one fourth, and less than one sixteenth, of the quantity of the latter. But he knows that when he enters a fiery mine his life is in his hand. He may not know that the barometer indicates a more or less dangerous condition, as a rule, in every fiery mine. But he does know that any blow of his pick may open a "blower," or jet of fire-damp, in the mine; that if this jet meets a naked light it will take fire; and that unless the ventilation sweeping through the mine be such as to maintain a complete control over the issue of the fire-damp, which is always to a certain extent going on, the workings will be wrapped in a blast of flame, and none will be left alive to tell how it occurs. He knows, too, that the "Geordie," the invention of an old miner, whose name should be held in honor by the British workman as that of a family saint or household god, instead of setting the "fire-jack" alight, will indicate its presence by a harmless explosion within its own tube, and will then become extinguished. Or if the mine in which he works be one in which the "Davy" lamp is used, instead of the "Geordie," he knows that the little cage of wire gauze will become filled with flame if placed near a "blower" or held in the top of a working where there is too much gas to be safe, but that the flame will not pass through the meshes of the protecting shield. His is not the class of mind which can be brought to regard the safety-lamp as a talisman, giving protection to the miner who works with a naked light close by his fire-proof companion. It is more than probable that the increased safety from explosions to which we have referred may be mainly, if not altogether, due to the action of the Government inspectors in preventing the use of powder in fiery mines. Where blasting is allowed, the onus of responsibility is taken from the shoulders of the miner, and thrown on those of the superintendent. But, in the last two terrible casualties which have brought desolation to so many homes in the Black Country, there has been no question of blasting. A sudden outpour of fire-damp must, in each of these cases, have come in contact with a naked light. In cases where no miner has been left alive to tell the tale, there has often been found a mute but unimpeachable witness. A lamp has been found unlocked, a candle half burned, a box of matches half consumed. One or more of the miners, in spite of regulation, in spite of inspection, in spite of peril of his life, has had a naked light in his possession. What can have induced him to run the risk?

It is not surprising that the question should have proved utterly insoluble to those who have never been underground; nay, more, to those who have never worked underground. In the absence of that personal experience which throws a very strong ray of light on the obscurity of the question, it is easy to take a leaf out of the book of a

certain group of teachers, and throw the whole blame on the "depravity of human nature." True, it is not conducive to delicacy of feeling or to accuracy of scientific perception to toil for hours together in the Cimmerian gloom of the coal mine. Very little idea can be formed, by forty-nine fiftieths of the population of this country, of the cost of human toil at which their houses are kept warm and bright. Especially when the coal is worked in thin beds is the toil of the miner all but intolerable. In some instances he actually lies full length on the floor of the working, clad in nothing but a scanty pair of drawers, working with his pick a little in advance of his head as he lies. Nor does he cast off the badge of toil when he returns to the light of day. The other day a colonel in the army, a man deeply interested in all mechanical and scientific improvement, who was staying in one of the great mining centers, happened to go to a public establishment in the town in order to take a Turkish bath. While he was waiting for his room, two miners came out, who had been enjoying that unusual luxury. "I say, Jack," said one of them, "Moll won't know me. She never saw my skin white." His wife had never seen him washed, except his face. This may be an extreme case; as in some of the Welsh districts the "tubbing" of the men on the Saturday night takes place before the doors of their houses. But we give the incident as it actually occurred.

But pass all this. Let us attribute to the miner as extravagant a perversity of nature as the most zealous missionary can insist upon—he is at all events something better than a beast. Even a beast has the instinct of self-preservation. In man it is, there can be no denial, usually the very keenest of his instincts. And whatever the miner may know, and of whatever he may be ignorant, from his first apprenticeship underground he has had held up to his imagination the fearful and ever-present peril of the fire-damp. Abuse him as we may—and for our own part we should be very sorry to speak of him in any terms but those of cordial respect—we have not got a single step on our journey toward the solution of the question, What makes him run a risk that he knows to be hazardous?

Reader, have you ever been underground—not for amusement or out of curiosity, but in the discharge of your duty? If so, have you ever been alone underground, in a solitary point of the workings? And, if so, have you ever, by any accident, found yourself left in total darkness. The writer has had this experience, and it is one that leads him to speak with somewhat more of human sympathy for the collier than might be natural for a literary man who is not also a workman.

The oppression of utter darkness on the human organization is terrible. And hardly less than the oppression of utter darkness is the irritation produced by inadequate light. When, as they begin to number seven times seven years, the gradual diminution in the focal length of the vision often suffers a rather rapid increase, persons who

have had the disagreeable experience know that the first intimation that they must have recourse to spectacles is one of the most painful experiences of ordinary human life. At all times the want of sufficient light to see by is a hard trial. The more need there is of attentive vision, or the more the eye perceives the failing of its own power, the more intolerable is the hardship. Now, in mining the attention has to be kept vividly directed to the effect of every blow of the pick. There are many kinds of work which can be done with but little exertion of eyesight. Mining is not one of them. In a fair face of coal the operation of "getting," as it is called, may be a straightforward one; but this is far from being always the case. We have seen, too, that it is not always to the face of the coal that the chief care of the miner has to be directed. One third of the lives lost are due to falls, of face or of roof. With every blow of the miner's pick that danger has to be borne in mind. It is a danger increased tenfold by obscurity. The experience of our public works is enough to prove that, if the workings of our mines could be made as light as day, both shaft accidents and accidents from fall of roof would be enormously diminished in number. Does the reader know how the miner has to ascertain whether the roof is coming in upon him, or whether the "creep" from below is overpowering his hastily fixed props and polling boards? We can tell him from experience.

A piece of damp clay is, or should be, always at hand in a mine. Frequently it is to be met with in the workings. If not, some should always be brought down. In cases where there is no fear of explosion, and indeed in all cases fifty years ago, a bit of wet clay forms the usual miner's candlestick. In cases where luxury is studied, a bit of wood with a hole in it carries the "farthing dip." But even this fastidious candlestick, if it has to be set down on the ground, is made secure from a casual overset by a dab of wet clay. Now, if any undue cracking is heard in the timbers, or if a rattle from above gives warning that the roof is not altogether in a stable condition, what does the miner do? He smears a bit of wet clay into any crack that he observes in a prop, polling board, or junction of the timbering of the mine, and then quietly watches, to see whether the damp clay cracks. If not, it is probable that the timbering is sufficient for its work. If it does, the timbering has, in all haste, to be strengthened. Peril of life is on the one hand, anxiety to see as clearly as possible on the other. The miserable ray thrown by the miner's lamp seems only to mock his anxiety. Is there any wonder if he affronts the more distant peril in his desire to avoid the more threatening one? His nose, he may think, will give him timely warning of the neighborhood of "fire-jack." To guard against the more fatal danger of roof-fall he has only his eyes. Is there any wonder that he seeks for more light, even at the risk of a naked flame?

We do not, of course, for a moment intimate that it is only for the

sake of looking to the safety of the roof that the miner has a naked light when he ought not to have one. But we think that there is little doubt that such is often the case. And we mention this only as one of those countless occasions, known only to those who have had subterranean experience, in which the desire for more light than that afforded by the ordinary safety-lamp may become uncontrollable. Our argument is, that some strong instinct of human nature must be at work in order to lead the miner to affront the known danger of explosion from the use of naked lights so frequently as we have but too much evidence that he is in the habit of doing. And we think that there is enough to account for this in the instinctive desire for light, and more especially in the maddening effect of obscurity when accuracy of vision is required.

If we have thus rightly judged, the first effect of the remark should be to remove a very heavy load of obloquy under which our colliers as a body have hitherto labored. More than that, the more any public writer has been acquainted with the chemistry of the coal mine, the louder has usually been his condemnation of the recklessness of the miner. No doubt, from the chemist's point of view, there is but too much reason for this. Avoid naked light and avoid blasting, and you avoid explosion. This logic is undeniable. But the chemistry of the mine is not the matter which most directly presses upon the miner. The mechanic, the physiologist, the optician, each has to be consulted. Grim fact shows that the chemical danger is, and always has been, affronted. The need of light explains why this has been the case. What, then, is the outcome of the whole inquiry?

It is this: The miner requires light. It is now half a century since science has done much to aid him in this respect. It was in or about the year 1815 that Sir Humphry Davy and George Stephenson entered on their honorable rivalry as to the safety-lamp. Foreign engineers have provided, in the lamps used in the deep Belgian mines, a sort of compound of the "Geordie" and the "Davy," under the name of the Mueseler lamp. MM. Liaute and Denoyel have invented an electric lamp, perfect as a scientific toy, but too cumbersome and liable to derangement for the rough usage of the miner. What is required is a lamp which shall at the same time give abundant light and afford perfect protection. It must not be cumbersome; it must not be heavy; it must not be costly. Miners have been known to dash in pieces the Upton and Roberts safety-lamp, merely from the irritation caused by its weight. If the miner can be provided with a lamp which, with the safety and the convenience of the "Davy," can give the light of eight or ten candles, can throw that light where it is wanted, and can do that at a moderate cost, the saving of life in our coal mines will be very great. For, by such an appliance, not only may the mortality caused by explosions be prevented, but that due to falls of roof, if not to other causes, may be most materially diminished.

This points to the inquiry, What is the true source of light? From what materials, as matter of principle, and apart from any question of the state of the science of illumination at the moment, is artificial light more certainly to be obtained?

To that question the reply is simple. We know, as matter of chemistry, what kind of combustion produces the greatest amount of light, as we also know what produces the greatest amount of heat. The two are by no means identical. Light can not be produced without the liberation of heat. On the other hand, a very high degree of heat can be developed when little or no light is produced. As matter of principle, this is the key to the question now to be reviewed.

We need not at the moment step aside to inquire into the future of the electric light. As to the cost at which that elegant source of concentrated brilliancy may be maintained, we are in the way of having experimental proof. The first great trial in London, that of the Jablochkoff candles at Billingsgate Market, has proved a failure, as regards both the quantity and the quality of the light produced, as well as with reference to the cost of production, and has in consequence been abandoned. But, be the cost of producing an equal quantity of light by the new or the old fashioned process of combustion the greater, the former is out of the question as far as coal mines are concerned. A brilliant light at the bottom of the shaft would of course be a great desideratum. But no one who has studied the plan of the workings of a coal mine can fail to be aware that nothing will supersede the miner's lamp. Each man who works at the face must be provided with his own light; and no general illumination, were such possible, would make up for the want of this. In vast underground caverns, such as that of the Peak, in Derbyshire, or such as those of some of the Cheshire salt mines, a brilliant and concentrated light may, no doubt, be extremely effective. But in speaking of the working of collieries, whether in the "long wall" system or on any modification of the "pillar and stall," we must look to such a lamp as each miner can carry for himself.

In speaking of illumination, we are as yet without any unit of light. Our measurements in this respect are made pretty much by rule of thumb. The sperm candle, burning or supposed to burn at the rate of one hundred and twenty grammes per hour, is our nominal unit. In ascertaining the illuminative power of gas, two of these candles are used by way of measure. But there is no check as to the accuracy of their consumption. The use of a screen made diaphanous in one portion by a little grease enables the analyst to form a very accurate appreciation of the illuminative power of two lights. The screen is placed between the two, and moved backward or forward until the spot caused by the grease vanishes, which is the case when the intensity of the transmitted is exactly equal to that of the reflected light. By accurately measuring the distances, and applying the rule that the

intensity of the radiant center is inversely proportionate to the square of the distance from the screen, a very reliable comparison is attainable. But the weak point is the variable and ill-defined character of the unit of comparison. In the French experiments this defect is to a great extent avoided by the use of a Carcel lamp, which not only is intended to consume a given quantity of oil per hour, but is further weighed at the commencement and at the close of each observation, so that a correction is made in case of any variation in the actual combustion. Still, the Carcel lamp is an arbitrary unit. It is equal to about 9·6 English standard sperm candles; but when we have said that, we have only compared one arbitrary unit with another. In the case of the unit of heat, although it has been arrived at in terms of capacity (as regards the water heated) and of Fahrenheit's thermometer, which is in itself an arbitrary scale, it so happens that the Joule equivalent is exactly equal to the quantity of heat that is liberated by the combustion (if chemically perfect) of half a grain of carbon. If we take the same unit for the measurement of light, it must further be specified that the combustion of the carbon must be so effected as to produce carbonic acid and not carbonic oxide, and that it must take place in atmospheric air, and not in pure oxygen, or any other medium. That being borne in mind, it is probable that the combustion of a definite quantity of carbon would prove a better measure of light than any that has yet been tried. It would, at all events, link the phenomena of luminiferous to those of calorific combustion, and afford a ready means of detecting waste of illuminative power.

Various analyses have been given of ordinary coal-gas. Indeed, not only does that gas vary according to the quality of the coal from which it is produced, but it differs according to the process by which it is produced from coal of the same quality. Experts are divided, for example, as to the degrees of heat at which it is best to effect the distillation of coal-gas. But for our present inquiry it is enough to assume the composition of coal-gas as analyzed by Mr. Vernon Harcourt, who gives the proportions of fifty-eight per cent. of carbon and twenty-three per cent. of hydrogen. The details are given by Mr. D. K. Clark, in his invaluable work, the "Manual of Rules, Tables, and Data for Mechanical Engineers." Of this gas thirty cubic feet, at the temperature of 62° Fahr., weigh one pound. And the heating power of one pound of this gas (chemically speaking) is given by the same analyst at 22,684 British units of heat, of which sixty-three per cent. is due to the combustion of the hydrogen, and thirty-seven per cent. to that of the carbon. It thus follows that coal-gas is far more highly effective as a fuel than it is as a source of illumination. Other analyses give a yet higher proportion of hydrogen, the heat-giving element.

There is, however, a mineral fuel in which this distribution of the elements is very different. Petroleum is a natural fluid, consisting of hydrogen and carbon, which has been distilled in the great laboratory

of nature, and which exists in large quantities in various parts of the world. It is, comparatively speaking, a very recent discovery. The first well was sunk in Pennsylvania in 1858. The first "flowing well," or bore hole from which the rock oil flows naturally, dates in 1861. From that date the annual production has increased with marvelous rapidity. In 1878 it was computed that several hundred million gallons were annually raised, although only about one-half per cent. of the 2,000 square miles of area in which the mineral oil is to be found was then worked. The oil is also known to exist in Virginia, in Ohio, in Kentucky, in California, in Canada, in South America, in China, in Japan, in Java, on the north coast of Africa, in Italy, France, Austria, Wallachia, Turkey, and Russia. There is every reason to suppose that an unfailing supply might be obtained by boring in the valley of the Jordan, in which rapid stream masses of bitumen are often found borne down to the salt waters of the Dead Sea. On the shores of the Caspian it is found in such abundance that it is used as fuel for steamers. At Cheeriley, about twenty-five miles to the west of Kertch, it is stated by Mr. Ross * that there are five wells owned by an Englishman, two of which produce about one hundred and thirty-five barrels of petroleum daily. Bitumen and bituminous shales producing oil are to be found in every country of Europe, and there is good reason to suppose that the existing stores of the liquid mineral are no less ample than those of the solid beds of coal.

As to cost, the crude petroleum oil is sold at the mouth of the wells, in Pennsylvania, at from 10*s.* to 15*s.* per ton, or from $\frac{1}{2}$*d.* to $\frac{3}{4}$*d.* per gallon. The refined petroleum at New York is worth about 6*d.* per gallon, but half of this is the price of the casks or other vessels that contain it. If a large and steady demand were to set up, it would be easy to construct ships of which the hold should be composed of a series of air-tight compartments, in wrought iron, into which the oil might be turned directly by means of mains, like gas or water mains in our cities, and from which it might be pumped on its arrival in the Thames or in the Mersey. The cost of the delivery of this liquid fuel may thus be expected to be, hereafter, less per ton than that of coal. It only needs the first expense, that of sinking the shaft. It will then mine itself, raise itself, carry itself, and may be made to load itself on shipboard. As to the cost of the process of refinement, we are without adequate information. But, in the event of a brisk demand for the refined oil, there can be little doubt that the usual course of manufacturing industry would be followed, and that an economical method would be applied.

It is thus of interest to compare the respective properties of coal, coal-gas, and petroleum, both as regards their lighting and their heating capacities, as far as the present state of definite scientific information attainable will allow us to do so.

* "Minutes of Proceedings of the Institution of Civil Engineers," vol. xl., p. 150.

Coal has now receded in England to the old minimum price of 4*s.* 6*d.* at the pit's mouth. Some of our northern railways are paying 6*s.* a ton for coal. The price of the best Wall's End coal delivered at private residences in London, at the end of January, 1879, was 29*s.* per ton. Thus, even in the three hundred miles which divide the metropolis from the pit's mouth, it will be seen that the price of coal is so regulated by local conditions, and distance from the collieries, that it is not easy to strike an average. We may therefore assume a price, equal to that of petroleum, of 10*s.* per ton, for the sake of comparison, and it will then be easy to apply the correction due to the price of coal in any particular spot. The undetermined charges for interest on capital, merchants' profits, and delivery to consumers, may also be roundly taken, for the sake of comparison, as equal for the different materials.

The cost of the manufacture and distribution of gas in London (exclusive of the cost of coal) is about twenty per cent. over the amount realized for the sale of the residual products of distillation, of course excluding the gas. 10,000 cubic feet of gas per ton is a high, though not the highest, production. The price of the residual products, as a rule, is so far regulated by the price of coal at the spot, that it is usually reckoned that the local price of gas in England is nearly independent of the local variation in the price of coal, sales balancing purchases. Thus, if we take 10,000 cubic feet of gas as costing the same as one ton of coal, we shall be within twenty or twenty-five per cent. of exactitude, as a general rule. We have, then, to compare the luminiferous and calorific value of a ton of coal, a ton of petroleum, and 10,000 feet of cubic gas, assuming the approximate price of each of these quantities to be equal.

For lighting purposes, indeed, coal is nowhere. It has been occasionally used for giving light on public works, such as railways, when it was necessary to carry them on by night. But the light of a "devil," or iron basket of live coals, is fitful and costly. As recently as 1815 the dangerous Bell Rock, at the entrance to the Firth of Tay, was lighted by a fire-basket, or "chauffer," of live coals. It is stated in the "Life of Robert Stevenson," the great lighthouse engineer, that the consumption of coal in this "chauffer" was four hundred tons per annum, while the light was never reliable when most required. In violent gales the coal never burned on the windward side of the fire; and the guardian actually laid hold of the bars of the "chauffer," on the windward, to steady himself while putting on more fuel. Thus, in the direction where, and at the time when, the light was most required, it was all but totally invisible. The gas requisite to maintain a light equal to one hundred Carcel burners, or nine hundred and sixty candles, for twelve hours, is producible from half a ton of coal, as distilled in the gas-works. This would yield a splendid light (if the locality were such as to allow of its introduction); while the consumption of twenty-two hundred weight per night of coal only made darkness visible.

As to the calorific properties of coal, it is well known that the theoretic quantity of heat that should be chemically liberated by the consumption of a given quantity of that fuel is more than ten times as much as that which is ordinarily obtained, even by well-constructed steam-boilers. For a pound of coal to evaporate eight pounds of water may be taken as a very favorable average. In domestic consumption there is nothing approaching to this economy of heat. A considerable quantity of unburned carbon passes up the chimney in the form of smoke; and probably three fourths of the heat actually liberated by combustion is carried off in the same manner by the draught.

According to the experiments made by Mr. Vernon Harcourt, before referred to as quoted by Mr. D. K. Clark in his "Manual of Rules, Tables, and Data," a pound of gas, with a volume of thirty cubic feet, will evaporate thirty pounds of water from 212°, or 21·4 pounds from 62°. This gas is reckoned at 9,000 cubic feet to the ton of coal; so that the evaporation (of one pound of water by one cubic foot of gas) is effected by the quantity of the latter derived from almost exactly a quarter of a pound of coal. At the more ordinary allowance of 10,000 cubic feet per ton, ·224 pound of coal yields a foot of gas. It has to be borne in mind that only about thirty-six per cent. of the coal ordinarily used for gas is volatilized in the process of distillation. Of the coke, which is the chief residual product, from fifty-eight to ninety-three per cent. is carbon; sulphur and other impurities going to make up the rest of the bulk. There are produced on the average thirteen and one-half hundred weight of coke, and ten gallons of tar, from a ton of coals, besides the gas. The calorific and luminiferous values of these residual products are thus much greater than that of the gas itself. But a better use can be made of tar than to burn it; and we have considered the value of these products as absorbed by the cost of the process of making gas.

With these qualifications, the calorific effect of the gas produced from a pound of coal is about half that which would be produced by the burning of a pound of coal under a well-constructed boiler, where of course both coke and tar are consumed together with the gas. But in cases of domestic consumption the economy in the use of gas will be immense. There is no waste, no smoke. Instead of seventy-five per cent. of the heat going up the chimney, nearly all will be directly utilized. There is no loss of heat in lighting the fire; none in cooling when the work is done; no labor in the carriage of coal to the furnace; none in the removal of the ashes. Bearing in mind all these sources of economy, the domestic use of gas for heating purposes is so advantageous that it is extraordinary that the introduction of so clean, cheap, and manageable a source of comfort should make such slow progress in England. In America the improvement is more rapid and more general.

For luminiferous purposes we have seen that there is no comparison between the consumption of crude coal and that of coal-gas. Allowing the mean proportion of 10,000 cubic feet of gas to the ton of coal which we have before taken, the consumption of an ordinary gas-burner, whether an argand or a fish-tail, is about five cubic feet per hour, giving a light of from twelve to sixteen candles, according to the richness of the gas. If we take Mr. Vernon Harcourt's analysis, thirty cubic feet, or one pound of gas, contains 4,060 grains of carbon. Five cubic feet therefore contain 67·6 grains, which will be the hourly consumption of pure carbon in an ordinary gas-light.

Petroleum, however, contains from eighty-two to eighty-seven per cent. of carbon, and from eleven to fifteen per cent. of hydrogen. Averaging this at eighty-four per cent. of the former and thirteen of the latter, a pound of petroleum contains 6,080 grains of carbon and 910 grains of hydrogen. Its luminiferous power is thus almost exactly fifteen times that of coal-gas, taking equal weights. Its calorific power, supposing a perfect combustion, will be ten per cent. less than that according to Mr. Vernon Harcourt's estimate, and less than half that of the highest estimate given by Mr. Clark.

It is thus as clear as any deduction from chemical data can be, that while the economy in the use of coal-gas as a source of heat is so great as to render it worth while to keep up the distillation of this product, as now carried on, for calorific purposes alone, even exclusive of its use for a light, for the purposes of illumination petroleum offers an immense advantage over coal-gas, its illuminating powers being as much as fifteen-fold. And when we are speaking, not of an organized system of fixed lights, but of the convenience of a hand lamp, the price and the illuminative value of petroleum indicate it as the source of the economical light of the future. In fact, its light-giving power is ten per cent. more than that of either tallow or olive-oil, and four per cent. more than that of wax, weight for weight, notwithstanding the great difference in price.

The question of the miner's safety, then, resolves itself into the construction of a petroleum lamp, which shall have the safety of the "Geordie," while giving the light of one, or even of two or three fish-tail burners of gas, and which shall be so made as neither to empty nor to be extinguished if laid on the side.

It is desirable, in an inquiry of this nature, to avoid anything that assumes the appearance of advertisement, or of an attempt to introduce anything of a commercial bearing. For that reason less must be said than honestly and fairly might be said as to the principles on which such a lamp may be unquestionably constructed. Two or three patents exist, which would require due consideration. It is always, indeed, doubtful how far recent patents will stand the test of thorough investigation. The latest patents for electric lighting are now found, in many cases, to be reproductions of methods long since introduced and

abandoned. Moreover, it may be hoped that if it were found that a great national benefit, such as a true miner's lamp would be, involved either a long delay before it could be offered to the collier, or serious compensation for an unexpectedly valuable patent right, no very exorbitant claim would be raised to avoid the saving of a human life per day.

The one simple principle on which a lamp, whether a safety-lamp or any other, may be made to yield the full light due to the perfect combustion of the carbon of its aliment, is one long known to the miner as applied to ventilation. A single shaft will not ventilate a mine. In the same way, if a lamp or a candle be surrounded by a glass shade only open at the top, it will not burn properly. The taller the glass chimney the redder and dimmer will be the flame, until it is actually extinguished by the product of its own combustion. This is usually avoided by a free admission of air below the chimney, which is not practicable in a safety-lamp. But if for one shaft two be substituted, or even if the single shaft be divided—the miners call it "bratticed"—into two vertical sections, a little heat will produce an upward current in the one, which will be fed by a descending current in the other. The lamp is only the mine in miniature.

Very brilliant results have already attended the introduction of a lamp constructed in accordance with this simple law, in the illumination of railway carriages. No mechanical man can doubt that a modification of the lamp now used in the royal saloon carriages might put in the hands of the miner a real life-preserver. It would be a lamp which, while impenetrable to fire-damp, or rather impenetrable from within as a source of explosion, would give him what he now wants—light in the darkness of the mine.

We have seen that, out of the half million of colliers, to whose perilous labors we owe the warmth and comfort of our homes, the speed and regularity of our traveling both by land and by sea, and the aliment of that mighty host of mechanical horses which now perform the bulk of the sheer hard labor required above-ground in the United Kingdom, a tax on human lives at the rate of at least ten lives per million tons of coal is exacted with much regularity. From a fourth to a half of these lives are sacrificed by preventable calamities. It is by satisfying the mute instinctive demand of the miner for light, in his painful and dangerous toil, that these casualties which are preventable can alone be certainly prevented. Is it necessary to say more in order to turn the attention of the collier and of the engineer, of the man of capital and of the man of science, of the economist and of the philanthropist, to the urgent question of providing the miner with a safe, convenient, and luminous lamp?

P. S.—Since the above was in type, has appeared the announcement of a Royal Commission of Inquiry into Mining Explosions, to the attention of which the above remarks may be respectfully commended.—*Fraser's Magazine.*

CHEMISTRY IN ITS RELATIONS TO MEDICINE.*

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IF we look back over the field of chemistry, we find that we can easily discern well-characterized periods in its development. At first, in this subject, as in all others, came the period of chaos, during which relations of similar facts were not recognized nor suspected. No defined object was in view; and the development during this period was due almost entirely to accidental observations of facts which presented themselves to men in pursuing their ordinary occupations. Gradually we find that a certain class of men began to make use of chemical facts, as far as they were then known, for a very definite purpose. This was, to convert ordinary base metals into that metal which possessed the greatest value—*gold*. This purpose gave a powerful incentive to the study of chemical phenomena, and, under the influence of the natural passion which affected a comparatively large number of men, the subject of chemistry grew apace. But the impossibility of accomplishing the great problem of the alchemists became more and more apparent. No gold *was* made from baser metals, and no genuine philosopher's stone was discovered; no panacea for all diseases was revealed. A reaction in scientific opinion then began, which led to very much modified views concerning the purpose of chemistry, until about the time of Paracelsus, who was both physician and chemist, we find that the opinion prevailed very generally, among those who were most active in investigating chemical phenomena, that the changes which take place in the animal body, under normal conditions, are nothing but chemical changes; that a disturbance of these normal changes causes the different varieties of disease; and, finally, that the treatment of disease must consist in administering such chemical substances as would restore the normal conditions. Paracelsus started these ideas, and others developed them, until they took the exaggerated form comprised in the above statements. According to these ideas, medicine was considered as a branch of chemistry, very much as metallurgy is now considered as a branch of chemistry. Hence the physicians of the date of which I am speaking—i. e., from the early part of the sixteenth until some time in the seventeenth century— regarded chemistry as the one important subject for those who were to deal with disease. Without a knowledge of this subject they could not comprehend the processes of life; without it they could not understand disease; without it they could not intelligently administer remedies.

* From the Annual Address delivered before the Medical and Chirurgical Faculty of Maryland.

I think we can see, in this reference to history, a tendency which has frequently been repeated since that time—a tendency to generalize upon an insufficient basis of facts concerning the action of remedies. The reasoning of these older physicians, stripped of all unnecessary details, was simply this: Some remedies act chemically upon the body and produce chemical effects, hence all remedies must act in the same way. Thus the chemico-medical school was founded, as many schools of medicine have since been founded. The dogmas of this old school contained a healthy nucleus of truth, to be sure, as do the dogmas of most schools of medicine existing at the present day, but the physician proper now recognizes that remedies act in very many ways, and that the science of medicine must take into consideration every way in which remedies can act. He does not commit the error of being satisfied with one idea, as, for instance, that substances do act chemically upon the body, that cold water is a valuable remedy, that electricity properly applied is at times beneficial. A single idea is not sufficient for him.

Still we must recognize the fact that, in order to impress upon the minds of men the importance of an idea, in order to attract attention to it, it is frequently necessary to present it in an exaggerated form. And so, while we see the error of the old physiciansof Paracelsus's time, we see also that, by attracting the attention of physicians and chemists to the connection between chemistry and medicine, the error committed resulted in permanent good to medicine, and the influence of the old school is still felt. The ideas of those who founded and developed the chemico-medical school have found their proper level, as all ideas tend to do sooner or later.

It would doubtless be interesting to follow closely the history of the connection between chemistry and medicine, but our time will not permit the discussion of this subject, and hence I shall speak of the bonds of connection indicated by actual chemical work of the present day.

In the first place, chemistry furnishes medicine with many of its valuable remedies, as every one knows. The chemist, however, does not recognize the discovery of new substances, possessed of medicinal properties, as the object of his work. If he did so, both chemistry and medicine would suffer. The prime object of the scientific chemist must always be to develop his science, to perfect it in every way he may find possible; he must be constantly on the lookout for discrepancies between facts supposed to be established, and must ever endeavor to correct errors into which his predecessors may have fallen; he must reach out beyond that which is known, and strive to know more. The object of the chemist can only be accomplished by employing every method peculiar to the science of chemistry, and by striving to know everything about a substance or class of substances which it is possible to discern. If the chemist should work with the main object of adding

to the valuable substances included in the materia medica, he would stop when he had established the fact that this substance—just born—has such and such medicinal properties. He might discover a few substances in this way, but, unless work of another kind were going on simultaneously, which would furnish him with new methods, with new guiding principles, the possibilities of new discoveries would soon be exhausted. It is absolutely necessary, then, that purely scientific and abstruse problems should engage the attention of chemists, if the science is to grow; and it is further necessary that the science should grow, in order that new methods for the discovery of new substances may be introduced. It is the chemist proper who furnishes the new method; it may be that the chemist proper also discovers the valuable remedy, though one who simply applies the truths of chemistry *may* make the discovery.

As a matter of fact, it can be shown that it is to the purely scientific chemist, working with the main object of building up the science, that we owe the discovery of most valuable remedies, at least of those which are strictly speaking chemical compounds. I select for this purpose two substances which have but comparatively recently found their places in the materia medica—viz., chloral and salicylic acid. How and by whom were these substances discovered and introduced into medicine?

Nearly fifty years ago the great master Liebig undertook the study of the decomposition which alcohol undergoes when treated with chlorine. Other observers had noticed the fact that alcohol is decomposed by chlorine and that an oily product is formed, but the nature and composition of this product were unknown. Liebig undertook then simply to study this decomposition for the sake of throwing light upon the general subject, the action of chlorine upon alcohols. His investigations soon led him to the discovery of a new substance which possessed peculiar chemical properties, distinguishing it from all other compounds then known. This was *chloral*—the name being derived from the first syllable of *chlor*ine and the first syllable of *al*cohol. Of the action of this substance upon the system, Liebig did not dream; but the study of its properties which he made at that time furnished the material that enabled Liebreich, forty years later, to dream in a very rational manner concerning its action upon the system. Liebreich's discovery of the value of chloral could not have been made by one unversed in chemistry. His experiments were undertaken in the true scientific spirit, and were suggested by a purely chemical method of consideration.

Among other facts concerning chloral which had been established by Liebig was this that in the presence of alkalies it breaks up into formic acid and the substance which we now know by the name chloroform. Chloroform was thus discovered by Liebig at the same time with chloral, but the action of the former upon the system was as little

known as that of the latter. Years after the effects produced by the inhalation of chloroform were discovered, Liebreich reasoned thus: If chloral breaks up in alkaline liquids into chloroform and formic acid, why should it not break up in the same way when introduced into the animal system? The conditions in the body are favorable for such a decomposition—the blood is an alkaline liquid and the chloral will dissolve in it. By means of this reasoning the discovery was made, and there is no cause to doubt that the beneficial effects experienced from chloral are due to the fact that the alkaline blood decomposes it, forming chloroform and formic acid, the chloroform being thus introduced into the system in a manner differing from that involved in the inhalation process.

As regards salicylic acid, its discovery was the result of a long series of purely scientific investigations. For years Kolbe had been trying to produce artificially in his laboratory some of the substances which are found in nature. He strove faithfully and conscientiously to accomplish his purpose, and at last he discovered a method which enabled him to make oxalic acid; and then, after the method was given, the production of other similar acids was simply a question of the application of the new method. Salicylic acid was among the products thus formed. The acid had been known for a long time, but, as it could be obtained only from the expensive oil of wintergreen, it belonged to the rare substances. Kolbe's method of preparation, however, furnished the substance in large quantities and at a low price.

The discovery of the valuable antiseptic properties of the acid was a pure scientific discovery, and was due to purely chemical reasoning. It was known that salicylic acid when heated breaks up directly into carbolic acid and what is commonly called carbonic acid. It occurred to Kolbe that possibly this property might be taken advantage of to furnish a substitute for the objectionable carbolic acid. The results of his experiments are well known: they were more satisfactory than he had hoped for. He found that salicylic acid is an excellent antiseptic. Though he has shown that, contrary to his expectation, the antiseptic action possessed by the acid is not due to its breaking up into carbonic and carbolic acid, still the action must be due to a similarity between the chemical structures of the two acids; and this similarity could not have been detected without the aid of some of the most refined methods of scientific chemistry. It is safe to say that blind experiment, unguided by definite chemical principles, could not have led to this discovery.

Thus I have at least illustrated the truth of the remark I made a few minutes since, to the effect that the discoveries of substances valuable in medicine are made by those engaged in the pursuit of pure science. I am aware that the two examples thus referred to will not suffice to furnish a perfect proof of the proposition; but, if time per-

mitted us to take a survey of the field, we should find that the proof could be made conclusive.

But the discovery of new substances to be used as remedies does not furnish the only bond of connection between medicine and chemistry. Nor is it by any means the most important one. For, as the tendency of the present generation of physicians is, I think, to rely less and less upon the action of drugs and chemicals, and to pay more and more attention to the circumstances surrounding the patient, so the discovery of purely remedial agents is becoming day by day of less importance, and the accurate study of those substances which we all necessarily make use of—air, water, food in its various forms—is becoming the great problem in medicine. Thank Heaven! the day of the old woman who knows what is "good for" everything is waning. She exists still in a thousand forms, sometimes in skirts and sometimes in trousers, but the natural growth of modern ideas will eradicate her, though the process will take generations for its completion.

What is pure air? What is pure water? What food is appropriate? These are questions which can only be answered by him who is versed in chemistry. The very fact that discussions are still going on in regard to these subjects indicates clearly that they can not be answered easily, and yet no one doubts their fundamental importance.

For years men were satisfied with the belief that an increase in the amount of carbonic acid, beyond a certain point, was the cause of the evil effects experienced in breathing "foul air." The old familiar stories that have been told to prove the injurious character of the gas are still told in lectures on chemistry, and text-books of chemistry, and in medical books without number. Still, as most of you probably know, it has long since been proved by direct experiment, beyond the possibility of a doubt, that the amount of this gas may be increased to one twentieth of the volume of the air without producing any serious or even disagreeable effects upon those who breathe the air thus contaminated. This is true, however, only when the carbonic acid is mixed with the air as a pure substance. If introduced in the ordinary way, by the breathing process, different results are obtained, and it is found that, under these circumstances, the quantity of carbonic acid can not exceed one part in 1,000 of air without serious effects upon those who breathe the air. The two results, apparently, do not harmonize, but, when we recognize the presence of other substances, of organic matters, in the air, which are given off from the body together with the carbonic acid, and in quantities proportional to the quantities of the latter, we can readily see that there may be some connection between the amount of the carbonic acid present and the fitness of the air for breathing purposes. Such organic matters can easily be detected in the air, and they have recently been found by a method which indicates the possibility of determining their quantity, though such determinations are, at present, far from possible. Air was passed through

a heated tube, and then passed into alcohol for the purpose of retaining the products formed by heating the organic substances. The alcohol gradually changed its color and became dark brown. This experiment, though exceedingly imperfect, at present points, I think, to the possibility of estimating the purity of air by a direct determination of the quantities of those constituents which probably are the really injurious ones; while, at present, for the want of a more reliable method, we are obliged to be satisfied with determining the quantity of carbonic acid, and then drawing conclusions with reference to the amount of the organic matters present.

Various attempts have been made to simplify the determination of the amount of carbonic acid in air, so that even those who are not skilled in chemical manipulation might have a ready means for pronouncing upon the quality of air. The simplest of the methods proposed is the minimetric process of Lunge, which has been used to some extent in this as well as other countries. To show you, however, in what an unsatisfactory state this matter of air analysis still is, I will simply say that experiments undertaken, within a few months, by Hesse,* have shown that Lunge's minimetric process does not give reliable results, and hence conclusions reached from determinations made by this method are not to be regarded as final.

Another point still in dispute concerns the presence of carbonic oxide in the air. This lower oxide of carbon is undoubtedly poisonous, and can not be taken into the lungs without serious effects. The presence of only a small proportion of this gas will suffice to produce death. Now, if it could be shown that there are certain causes at work which apparently tend to introduce the gas into our dwellings and other buildings, alarm would naturally follow. Some years ago St. Claire-Deville, the French chemist, discovered that certain metals, when heated to red-heat, are porous for certain gases. This he found to be true of cast iron with reference to carbonic oxide. It is well known that in our coal-fires there is always formed a large quantity of carbonic oxide; and, further, that stoves and furnaces not uncommonly become red-hot. Putting these facts together, men became alarmed. Stoves and furnaces were regarded with horror. In the eyes of many they were looked upon as poison-generators of a very dangerous kind. Active diseases were, in some cases, believed to have their origin in the presence of carbonic oxide in the air; and, in cases in which active disease did not show itself, lassitude, headache, and other similar symptoms were supposed to be caused by the gas. There was a fashion, in some places, and particularly among those who prided themselves on "keeping up with the times," of referring every bodily affection to carbonic oxide when no other cause could be thought of, very much as, in days gone by, every disease which was not understood was classed under the general head "trouble with the liver."

* "Zeitschrift für Biologie," Bd. xiii., 395.

What basis of facts have we for this alarm about carbonic oxide? Two chemists, within a very short time, have gone to work to determine the amount of the gas contained in the air in places where it was assumed to be present in considerable quantity. And with what results? Why, the specter vanished. In vain they sought for it—in this corner, in that, in the chimney, in the hot-air passages—but it was not there. There seems to be nothing left for the carbonic-oxide alarmists but to yield, and set about looking for another cause.

The special experiments to which I refer were carried out by Gottschalk in Leipsic, and Vogel * in Berlin. Gottschalk, in a pamphlet entitled "Ueber die Nachweisbarkeit des Kohlenoxyds in sehr kleinen Mengen, und einige Bemerkungen zu der sogenannten Luftheizungsfrage," describes a process by means of which he could detect, as he shows by direct experiment, 0·22 part of carbonic oxide in 1,000 parts of air. He was commissioned by the authorities of the city of Leipsic to apply this process to the examination of the air in two of the public schools in the city. Two different kinds of hot-air furnaces were employed in these schools, and it was supposed that the air of the rooms was certainly contaminated with carbonic oxide. The experiments, however, proved that, if present at all, the gas could not be detected by a method capable of determining with certainty the presence of ·22 part in 1,000.

Vogel's experiments are not so delicate as those of Gottschalk, but still they are interesting for other reasons. His method consists in shaking the air under examination with water which contains a drop or two of blood, and then examining the liquid by means of a pocket-spectroscope. If ·4 per cent. of carbonic oxide be present the result is plainly perceptible in the spectrum of the light which has passed through the blood. The authorities of the city of Berlin commissioned Vogel, together with two other well-known experts, to examine the air of a number of schoolrooms in the city, with particular reference to the presence of carbonic oxide. The conclusion was simply that none of the gas could be detected by the blood method. Vogel argues further that a quantity of carbonic oxide in the air which can not be detected by his method can not act poisonously upon the concentrated blood of the human lungs.

Of course the experiments described do not prove conclusively that air is not sometimes rendered unwholesome by carbonic oxide, but they at least prove that this gas is not so widely distributed as it has been supposed to be for some time past.

Another constituent of the air which has from time to time attracted considerable attention is ozone. This has been supposed to be a health-giving principle in the atmosphere, and magical properties have been ascribed to it. The vitality of men is known to be subject to marked variations. On a cool, clear, bracing day the man is not

* "Berichte der deutschen chemischen Gesellschaft," xi., 235.

what he is on a warm and murky day. The quantity of ozone in the air also varies. Perhaps our moods, our "spirits," are dependent upon ozone. Give us ozone enough, and the world will be happier and healthier. These are some of the ideas which have been advanced. Possibly there is some connection between these two very unlike things. Certainly much more accurate experiments than any which have thus far been made, are called for to prove the connection.

In the light of many experiments it appears exceedingly probable that one of the most important constituents of the air is aqueous vapor, and that variations in its quantity beyond certain limits are productive of serious results. The influence of carbonic acid, carbonic oxide, or ozone, upon the value of air is almost nothing as compared with the influence exerted by the moisture. This is a point that does not ordinarily receive the amount of attention which it deserves. A reliable hygrometer should be as frequently used in a dwelling as a reliable thermometer. It is undoubtedly a very difficult thing to regulate the amount of moisture in the atmosphere of dwellings, but more could be done than is done. The methods now adopted for this purpose are mostly exceedingly imperfect. Further, the importance of doing everything to regulate the amount is not sufficiently recognized, at least by the people at large.

As regards the water we drink, every one knows that cases are very common in which it becomes polluted in one way or another, and that disease results from its use. Innumerable chemical examinations of drinking-water have been made, and large numbers of methods proposed for the analysis. Some of the methods have been shown to be utterly unreliable; others to be questionable; very few indeed to give results which can be regarded as at all valuable. It is about as difficult at the present day to say what pure water is as it is to say what pure air is. Papers upon papers are written on the subject of water analysis. Some of these are based upon experiments performed; some are simply critical. Out of the mass of literature we gather some truths. One that stands out prominently is this, that the presence of chlorine, of organic matters, of ammonia, and of so-called "albuminoid ammonia," indicates that the water containing them is very probably contaminated through sewage, cesspool, privy, or barnyard refuse. By the later methods of analysis, the estimations of the quantities of the substances mentioned have become comparatively simple processes, so that now it is undoubtedly possible to pass a fairly reliable judgment upon the value of a given specimen of water. It is, however, still quite impossible to determine by chemical methods whether the typhoid-poison is present in water or not, just as it is still impossible to determine whether in the air there is present that indefinite something known as "malaria." There is still a great deal to be done in order that a close connection between disease and the condition of drinking water may be established. The open questions are to a con

siderable extent chemical questions, and they must be answered by the chemist. But new methods must be introduced of a more refined nature than most of those in use at present, and these methods will probably be discovered in paths leading far away from the field of mediicne proper.

There is a deep question of great importance to the physician involved in the study of food: What food should this or that person indulge in? Every physician knows that the whole subject of food is at present in an indefinite, unsatisfactory condition. Fashions change in regard to kinds of food considered advisable. Now it is raw beef, now milk, now certain vegetables, etc. Of course, there is always a good reason to be given for the advice, whatever it may be, but it is certain that a good firm basis is still wanting for an understanding of the needs of the body under different conditions. Here is a great field for investigation; and Voit, of Munich, is doing what it is possible for a man to do in this direction.

But, aside from the deeper question which chemistry must answer as to the requirements of the body in the way of food, another question, which presents itself at once to the physician and chemist, concerns the adulterations of food. Very little of a general character can be said in this connection. It is, of course, the duty of the physician to see that the food partaken of is what it ought to be. That adulteration of various kinds of food is a frequent occurrence can not be doubted. In despotic countries, inspectors of food are appointed, and heavy penalties are imposed upon those who sell adulterated articles. We can hardly hope ever to have such strict regulations in regard to these matters in this country. The free-born citizen, especially if he be a manufacturer or dealer in suspected articles, naturally rebels against interference with his rights; and the manufacturer is not to be treated lightly. His voice is loud in the halls of legislation; and, what *he* does not want, the average legislator is pretty sure not to want. The relations with reference to food adulterations are similar to those existing with reference to fertilizers. The value of many fertilizers depends upon the amount of phosphoric acid and ammonia contained in them. I know that in some places there are chemists who habitually find considerably more phosphoric acid and more ammonia in any given fertilizer than it actually contains. If a young chemist dares to find the amounts actually present, and to state the results, the manufacturer discards them, and takes the highest and false ones obtained by the initiated chemist. This can only be characterized by the name swindling. The public must submit. The manufacturer's interests are not to be trifled with. Looking at the subject of food adulterations from the standpoint of the public, it can only appear highly desirable that some action should be taken by our State governments looking to vigorous interference with the traffic in impure and injurious substances.

Having thus touched upon the general subject of the relations of chemistry to materia medica and to hygiene, it remains for me to consider briefly the relations between chemistry and medicine in a deeper and broader sense. We can not at the present day, like our predecessors, regard medicine as a branch of chemistry. There are many kinds of action, not chemical, which must be studied and understood by the physician. Still, undoubtedly many of the physiological processes are essentially of a chemical nature, and there are many pathological phenomena which are also chemical. The complex organism which is the physician's field of work employs a variety of forces, prominent among which is the chemical force. It would be a trite remark to say that the physician can not possibly have a complete comprehension of what is going on within the body without a fair knowledge of chemistry. Yet I fear this fact is not always fully realized, nor indeed generally, if we are to take as evidence the practice of most medical schools.

Writing a quarter of a century ago, Liebig used these words, which I can not do better than to repeat: "Physiological and chemical researches in the field of medicine are only in their infancy, but scarcely begun; they have furnished the conviction that the processes in the living body rest upon natural laws, and every day brings discoveries, which prove that these laws can be investigated. It is true that in ages gone by there were excellent physicians who knew nothing of anatomy, and that for centuries diseases have been cured, the nature of which was not understood, just as to-day the nature of 'fever' and 'inflammation' is not known; but there is not the slightest foundation for the conclusion that an exact insight into these processes is impossible." And again he says: "Without correct ideas in regard to force, cause, action; without a practical insight into the nature of natural phenomena; without a thorough physiological and chemical training, it is no wonder that otherwise sensible men defend the most nonsensical views."

These words of Liebig are just as forcible to-day as the day they were written, and just as applicable.

The special value of a training in chemistry for a physician does not necessarily depend upon the fact that he learns a host of useful things, that he learns how to analyze substances, etc. To be sure, these acquisitions are valuable to him. But, if chemistry is to do for him what it can do, he must work so long and so conscientiously in its field as to enable him to acquire the "chemical sense." He must learn to think in the language of chemistry. He must reason as chemists reason—not as deeply, of course, but in the same general way. Then chemistry will be to him a constant aid, whose presence he will feel whenever he is brought face to face with life, either in its normal or its abnormal forms.

But, even if he did not retain a single chemical fact, the training

which he would receive by going through a course in chemistry would be of value to him. His eye and mind would become somewhat accustomed to dealing with natural phenomena. His powers of observation would be exercised, and a certain ability to distinguish between the important and that which is secondary would be cultivated. With such preparation, and other appropriate accompanying preparation, he would be much better able to undertake the study of medicine proper than without it. Hence it is much better to introduce the study of medicine by that of chemistry and other allied subjects, than to take up all the subjects together. The study of chemistry should form a part of the preliminary, fundamental training of every medical student.

That, owing to the arrangements of our medical schools, very little time can be given to chemistry is a misfortune. The amount of the subject usually taught is scarcely worth the trouble of acquiring it. I know what the amount usually is. I remember distinctly that, on the occasion of my graduation as a doctor of medicine, I was asked six questions which any one who had ever looked at a text-book of chemistry could have answered. I answered most of the questions incorrectly, as I have since discovered, but the Professor thought I was right, and I thought so too, and that was all that was necessary. Instead of possessing the "chemical sense," I was the possessor of considerable chemical nonsense.

But, while it requires no arguments to prove that a chemical training is desirable for the physician, it is not sufficient simply to acknowledge the truth of the statement. If it is true, then it is the sacred duty of every one, who has any influence with those who have a medical career in view, to put them upon the right track, to see that the best kind of preliminary training is furnished them.

By what I have said, I do not mean to imply that the physician is to be a chemist. This is an impossibility. "No man can serve two masters." I mean simply that he should have sufficient chemical knowledge to enable him to see when chemistry can answer a question of importance to medical science, and to know what value to attach to a chemical fact. It is plain that this kind of knowledge, which, so to speak, should pervade the mind of the physician, can only be acquired by studying pure chemistry as a science, and not by taking up the special study of physiological chemistry or medical chemistry. These latter rest upon pure chemistry, and can only be studied intelligently upon this basis. The specialist in medicine does not study eye-diseases or lung-diseases or diseases of the nerves, without first studying medicine. The analogy suggests itself.

But chemistry, even sufficient for the medical man, can not be studied alone by means of lectures and text-books. The medical student should be brought, in the laboratory, in direct contact with the substances, the relations and properties of which he is studying. By

this means alone can he learn enough of the subject to be of value to him; by this means alone can he get the peculiar training which leads to that kind of mind known as the "scientific mind"—a something which is tangible and attainable, and which should be a characterizing feature of every medical man.

THE HISTORY OF GAMES.

By EDWARD B. TYLOR, F. R. S.

BEFORE examining some groups of the higher orders of games, with the view of tracing their course in the world, it will be well to test by a few examples the principles on which we may reason as to their origin and migrations. An intelligent traveler among the Calmucks, noticing that they play a kind of chess resembling ours, would not for a moment entertain the idea of such an invention having been made more than once, but would feel satisfied that we and they and all chess-players must have had the game from one original source. In this example lies the gist of the ethnological argument from artificial games, that, when any such appears in two districts, it must have traveled from one to the other, or to both from a common center. Of course this argument does not apply to all games. Some are so simple and natural that, for all we can tell, they may often have sprung up of themselves, such as tossing a ball or wrestling; while children everywhere imitate in play the serious work of grown-up life, from spearing an enemy down to molding an earthen pot. The distinctly artificial sports we are concerned with here are marked by some peculiar trick or combination not so likely to have been hit upon twice. Not only complex games like chess and tennis, but even many childish sports, seem well-defined formations, of which the spread may be traced on the map much as the botanist traces his plants from their geographical centers. It may give us confidence in this way of looking at the subject if we put the opposite view to the test of history and geography to see where it fails. Travelers, observing the likeness of children's games in Europe and Asia, have sometimes explained it on this wise: that, the human mind being alike everywhere, the same games are naturally found in different lands, children taking to hockey, tops, stilts, kites, and so on, each at its proper season. But, if so, why is it that in outlying barbarous countries one hardly finds a game without finding also that there is a civilized nation within reach from whom it may have been learned? And, what is more, how is it that European children knew nothing till a few centuries ago of some of their now most popular sports? For instance, they had no battledoor and shuttlecock and never flew

kites till these games came across from Asia, when they took root at once and became naturalized over Europe. The origin of kite-flying seems to lie somewhere in southeast Asia, where it is a sport even of grown-up men, who fight their kites by making them cut one another's strings, and fly birds and monsters of the most fantastic shapes and colors, especially in China, where old gentlemen may be seen taking their evening stroll, kite-string in hand, as though they were leading pet dogs. The English boy's kite appears thus an instance, not of spontaneous play-instinct, but of the migration of an artificial game from a distant center. Nor is this all it proves in the history of civilization. Within a century, Europeans becoming acquainted with the South Sea Islanders found them down to New Zealand adepts at flying kites, which they made of leaves or bark-cloth, and called *mánu*, or "bird," flying them in solemn form with accompaniment of traditional chants. It looks as though the toy reached Polynesia through the Malay region, thus belonging to that drift of Asiatic culture which is evident in many other points of South Sea Island life. The geography of another of our childish diversions may be noticed as matching with this. Mr. Wallace relates that, being one wet day in a Dyak house in Borneo, he thought to amuse the lads by taking a piece of string to show them *cat's-cradle*, but to his surprise he found that they knew more about it than he did, going off into figures that quite puzzled him. Other Polynesians are skilled in this nursery art, especially the Maoris of New Zealand, who call it *maui*, from the name of their national hero, by whom, according to their tradition, it was invented; its various patterns represent canoes, houses, people, and even episodes in Maui's life, such as his fishing up New Zealand from the bottom of the sea. In fact, they have their pictorial history in cat's-cradle, and, whatever their traditions may be worth, they stand good to show that the game was of the time of their forefathers, not lately picked up from the Europeans. In the Sandwich Islands and New Zealand it is on record that the natives were found playing a kind of draughts which was not the European game, and which can hardly be accounted for but as another result of the drift of Asiatic civilization down into the Pacific.

Once started, a game may last on almost indefinitely. Among the children's sports of the present day are some which may be traced back toward the limits of historical antiquity, and, for all we know, may have been old then. Among the pictures of ancient Egyptian games in the tombs of Beni Hassan, one shows a player with his head down so that he can not see what the others are doing with their clinched fists above his back. Here is obviously the game called in English *hot-cockles*, in French *main-chaude*, and better described by its mediæval name of *qui fery?* or "who struck?"—the blindman having to guess by whom he was hit, or with which hand. It was the Greek *kollabismos*, or buffet-game, and carries with it a tragical asso-

ciation in those passages in the Gospels which show it turned to mockery by the Roman soldiers: "And when they had blindfolded him . . . . they buffeted him . . . . saying, Prophesy unto us, Christ, Who is he that smote thee?" (Luke xxii. 64; Matt. xxvi. 67; Mark xiv. 65).

Another of the Egyptian pictures plainly represents the game we know by its Italian name of *morra*, the Latin *micatio*, or flashing of the fingers, which has thus lasted on in the Mediterranean districts over three thousand years, handed down through a hundred successive generations who did not improve it, for from the first it was perfect in its fitting into one little niche in human nature. It is the game of guessing addition, the players both at once throwing out fingers and in the same moment shouting their guesses at the total. Morra is the pastime of the drinking-shop in China as in Italy, and may, perhaps, be reckoned among the items of culture which the Chinese have borrowed from the Western barbarians. Though so ancient, morra has in it no touch of prehistoric rudeness, but must owe its origin to a period when arithmetic had risen quite above the savage level. The same is true of the other old arithmetical game, *odd-and-even*, which the poet couples with riding on a stick as the most childish of diversions, "Ludere *par impar*, equitare in arundine longa." But the child playing it must be of a civilized nation, not of a low barbaric tribe, where no one would think of classing numbers into the odd-and-even series, so that Europeans have even had to furnish their languages with words for these ideas. I asked myself the question whether the ancient Aryans distinguished odd from even, and curiously enough found that an answer had been preserved by the unbroken tradition not of Greek arithmeticians, but of boys at play. A scholiast on the Ploutos of Aristophanes, where the game is mentioned, happens to remark that it was also known as *ζυγὰ ἢ ἄζυγα*, "yokes or not-yokes." Now, this matches so closely in form and sense with the Sanskrit terms for even and odd numbers, *yuj* and *ayuj*, as to be fair evidence that both Hindoos and Greeks inherited arithmetical ideas and words familiar to their Aryan ancestors.

Following up the clews that join the play-life of the ancient and modern worlds, let us now look at the ball-play, which has always held its place among sports. Beyond mere tossing and catching, the simplest kind of ball-play is where a ring of players send the ball from hand to hand. This gentle pastime has its well-marked place in history. Thus the ancient Greeks, whose secret of life was to do even trivial things with artistic perfection, delighted in the game of Nausikaa, and on their vases is painted many a scene where ball-play, dance, and song unite in one graceful sport. The ball-dance is now scarcely to be found but as an out-of-the-way relic of old custom; yet it has left curious traces in European languages, where the *ball* (Low Latin *balla*) has given its name to the dance it went with (Italian *ballare*, *ballo*, French *bal*, English *ball*) and even to the song

that accompanied the dance (Italian *ballata*, French *ballade*, English *ballad*). The passion of ball-play begins not with this friendly, graceful delivery of the ball into the next hand, but when two hostile players or parties are striving each to take or send it away from the other. Thus, on the one hand, there comes into existence the group of games represented by the Greek *harpaston*, or seizing-game, where the two sides struggled to carry off the ball. In Brittany this has been played till modern times with the hay-stuffed *soule* or *sun*-ball, as big as a football, fought for by two communes, each striving to carry it home over their own border. Émile Souvestre, in his "Derniers Bretons," has told the last story of this fierce game in the Ponthivy district—how the man who had had his father killed and his own eye knocked out by François, surnamed le Souleur, lay in wait for that redoubted champion, and got him down, soule and all, half-way across the boundary stream. The murderous soule-play had to be put down by authority, as it had been years before in Scotland, where it had given rise to the suggestive proverb, "All is fair at the ball of Scone." The other class of hostile ball-games differs from this in the ball having not to be brought to one's own home, but sent to the goal of the other side. In the Greek *epikoinos*, or common-ball, the ball was put on the middle line, and each party tried to seize it and throw it over the adversary's goal-line. This game also lasted on into modern Europe, and our proper English name for it is *hurling*, while *football* also is a variety of it, the great Roman blown leather ball (*follis*) being used instead of the small hand-ball, and kicked instead of thrown. Now, as hurling was an ordinary classical game, the ancients need only have taken a stick to drive the ball instead of using hands or feet, and would thus have arrived at *hockey*. But Corydon never seems to have thought of borrowing Phillis's crook for the purpose it would have so exactly suited. No mention of games like hockey appears in the ancient world, and the course of invention which brought them into the modern world is at once unexpected and instructive.

The game known to us as *polo* has been traced by Sir W. Ouseley, in Persia, far back in the Sassanian dynasty, and was at any rate in vogue there before the eighth century. It was played with the long-handled mallet called *chugán*, which Persian word came to signify also the game played with it. This is the instrument referred to in the "Thousand and One Nights," and among various earlier passages where it occurs is the legend told by the Persian historian of Darius insulting Alexander by sending him a ball and mallet (*guï ve chugán*) as a hint that he was a boy more fit to play polo than to go to war. When this tale finds its way to Scotland, in the romance of King Alisaunde, these unknown instruments are replaced by a whipping-top, and Shakespeare has the story in the English guise of a newer period in the scene in "Henry V.": "What treasure, uncle?"—"Tennis-balls, my

liege." By the ninth century the game of *chugán* had established itself in the Eastern Empire, where its name appears in the barbarous Greek form *τζυκανίζειν*. In the Byzantine descriptions, however, we find not the original mallet, but a long staff ending in a broad bend filled in with a network of gut-strings. Thus there appear in the East, as belonging to the great sport of ball-play on horseback, the first shapes of two implements which remodeled the whole play-life of mediæval and modern Europe, the chugán being the ancestor of the mallets used in pall-mall and croquet, and of an endless variety of other playing clubs and bats, while the bent staff with its network was the primitive racket. The fine old Persian drawing of a match at chugán, which is copied by Ouseley in his "Travels in the East," justifies his opinion that the horseback game is the original. We should not talk of polo as being "hockey on horseback," but rather regard hockey as dismounted polo, and class with it pall-mall, golf, and many another bat-and-ball game. Indeed, when one comes to think of it, one sees that no stick being necessary for the old foot-game of hurling, none was used, but, as soon as the Persian horsemen wanted to play ball on horseback, a proper instrument had to be invented. This came to be used in the foot-game also, so that the Orientals are familiar both with the mounted and dismounted kinds. The horseback game seems hardly to have taken hold in Europe till our own day, when the English brought it down from Munniepoor, and it has now under the name of *polo* become a world-wide sport again. But the foot-game made it way early into Europe, as appears from a curious passage in Joinville's "Life of St. Louis," written at the end of the thirteenth century. Having seen the game on his crusade, and read about it in the Byzantine historians, he argues that the Greeks must have borrowed their *tzycanisterium* from the French, for it is, he says, a game played in Languedoc by driving a boxwood ball with a long mallet, and called there *chicane*. The modern reader has to turn this neat and patriotic argument upside down, the French *chicane* being only a corruption of the Persian *chugán*; so that what Joinville actually proves is, that before his time the Eastern game had traveled into France, bringing with it its Eastern name. Already, in his day, from the ball-game with its shifts and dodges, the term *chicane* had come to be applied by metaphor to the shuffles of lawyers to embarrass the other side, and thence to intrigue and trickery in general. English has borrowed *chicane* in the sense of trickery, without knowing it as the name of a game. Metaphors taken from sports may thus outlast their first sense, as when again people say, "Don't *bandy* words with me," without an idea that they are using another metaphor taken from the game of hockey, which was called *bandy* from the curved stick or club it was played with.

In France, the name of *crosse*, meaning a crutch, or bishop's crosier, was used for the mallet, and thence the game of hockey has its

ordinary French name, *jeu de la crosse*. In Spanish, the game has long been known as *chueca*. The Spaniards taught it to the natives of South America, who took kindly to it, not as mere boys' play, but as a manly sport. It is curious to read accounts by modern European travelers, who seem not to recognize their own playground game when transplanted among the Araucanians of Chili, even though it shows its Spanish origin by the name of *chueca*. Seeing this, one asks whence did the North American Indians get their famous ball-play, known from California right across the Indian country? It is to all intents the European *chueca*, *crosse*, or *hockey*, the deerskin ball being thrown up in the middle, each of the two contending parties striving to throw or drive it through the adversaries' goal. The Iroquois say that in old times their forefathers played with curved clubs and a wooden ball, before the racket was introduced, with which to strike, carry, or throw the leather ball. Of all the describers of this fine game, Catlin has best depicted its scenes with pen and pencil, from its beginning with the night ball-play dance, where the players crowded round their goals, held up and clashed their rackets, and the women danced in lines between, and the old men smoked to the Great Spirit and led the chant for his favor in the contest. The painter would never miss a ball-play, but sit from morning till sundown on his pony, studying the forms of the young athletes in their "almost superhuman" struggles for the ball, till at last one side made the agreed number of goals, and divided with yells of triumph the fur robes and tin kettles and miscellaneous property staked on the match. Now, as to the introduction of the game into North America, the Jesuit missionaries in New France, as early as 1636, mention it by their own French name of *jeu de crosse*, at which Indian villages contended "à qui crossera le mieux." The Spaniards, however, had been above a century in America, and might have brought it in, which is a readier explanation than the other possible alternative that it made its way across from southeast Asia.

When the middle ages set in, the European mind at last became awake to the varied pleasure to be got out of hitting a ball with a bat. The games now developed need not be here spoken of at length proportioned to their great place in modern life, as the changes which gave rise to them are so comparatively modern and well known. The Persian apparatus kept close to its original form in the game of *pall-mall*, that is, "ball-mallet," into which game was introduced the arch or ring to drive the ball through, whereby enough incident was given to knocking it about to make the sport fit for a few players, or even a single pair. An account of pall-mall and its modern revival in *croquet* will be found in Dr. Prior's little book. Playing the ball into holes serves much the same purpose as sending it through rings, and thus came in the particular kind of bandy called *golf*, from the clubs used to drive the ball. The *stool-ball*, so popular in mediæval merrymak-

ings, was played with a stool, which one protected by striking away with his hands the ball which another bowled at it ; the in-player was out if the stool was hit, or he might be caught out, so that here is evidently part of the origin of cricket, in which the present stumps seem to represent the stool. In *club-ball* a ball was bowled and hit with a club ; and a game called *cat-and-dog* was played in Scotland two centuries ago, where players protected not wickets but holes from the wooden cat pitched at them, getting runs when they hit it. We have here the simple elements from which the complex modern cricket was developed. Lastly, among the obscure accounts of ancient ball-play, it is not easy to make out that the ball was ever sent against an opposite wall for the other player to take it at the bound and return it. Such a game, particularly suited to soldiers shut up in castle-yards, became popular about the fourteenth century under the name of *pila palmaria*, or *jeu de paulme*, which name indicates its original mode of striking with the palm of the hand, as in *fives*. It was an improvement to protect the hand with a glove, such as may still be seen in the ball-play of Basque cities, as at Bayonne. Sometimes a battledoor faced with parchment was used, as witness the story of the man who declared he had played with a battledoor that had on it fragments of the lost decades of Livy. But it was the racket that made possible the "cutting" and "boasting" of the mediæval tennis-court, with its elaborate scoring by "chases." No doubt it was the real courtyard of the château, with its penthouses, galleries, and grated windows, that furnished the tennis-court with the models for its quaintly artificial grilles and lunes so eruditely discussed in Mr. Julian Marshall's "Annals of Tennis." A few enthusiastic amateurs still delight in the noble and costly game, but the many have reason to be grateful for lawn-tennis out of doors, though it be but a mild version of the great game, to which it stands as hockey to polo or as draughts to chess.

Turning now to the principal groups of sedentary games, I may refer to the evidence I have brought forward elsewhere,* that the use of lots or dice for gambling arose out of an earlier serious use of such instruments for magical divination. The two conceptions, indeed, pass into one another. The magician draws lots to learn the future, and the gambler to decide the future, so that the difference between them is that between "will" and "shall." But the two-faced lot that can only fall head or tail can only give a simple yes or no, which is often too simple for either the diviner or the gambler. So we find African negroes divining with a number of cowries thrown together to see how many fall up and how many down ; and this, too, is the Chinese method of solemn lot-casting in the temple, when the falling of the spoon-like wooden lots, so many up and so many down, furnishes an intricate result which is to be interpreted by means of the

* "Primitive Culture," chap. iii.

book of mystic diagrams. When this combination of a number of two-faced lots is used by gamblers, this perhaps represents the earlier stage of gaming, which may have led up to the invention of dice, in which the purpose of variety is so much more neatly and easily attained. The first appearance of dice lies beyond the range of history, for, though they have not been traced in the early periods in Egypt, there is in the Rig-Veda the hymn which portrays the ancient Aryan gambler stirred to frenzy by the fall of the dice. It is not clear even which came first of the various objects that have served as dice.

In the classic world girls used the astragali or hucklebones as playthings, tossing them up and catching them on the back of the hand; and to this day we may see groups of girls in England at this ancient game, reminding us of the picture by Alexander of Athens, in the Naples Museum, of the five goddesses at play. It was also noticed that these bones fall in four ways, with the flat, concave, convex, or sinuous side up, so that they form natural dice, and as such they have been from ancient times gambled with accordingly. In India Nature provides certain five-sided nuts that answer the purpose of dice. Of course, when the sides are alike, they must be marked or numbered, as with the four-sided stick-dice of India, and that which tends to supersede all others, the six-sided *kubos*, which gave the Greek geometers the name for the *cube*. Since the old Aryan period many a broken gamester has cursed the hazard of the die. We moderns are apt to look down with mere contempt at his folly. But we judge the ancient gamester too harshly if we forget that his passion is mixed with those thoughts of luck or fortune or superhuman intervention which form the very mental atmosphere of the soothsayer and the oracle-prophet. With devout prayer and sacrifice he would propitiate the deity who should give him winning throws; nor, indeed, in our own day have such hopes and such appeals ceased among the uneducated. To the educated it is the mathematical theory of probabilities that has shown the folly of the gamester's staking his fortune on his powers of divination. But it must be borne in mind that this theory itself was, so to speak, shaken out of the dice-box. When the gambling Chevalier de Méré put the question to Pascal in how many throws he ought to get double-sixes, and Pascal solving the problem started the mathematical calculation of chances, this laid the foundation of the scientific system of statistics which more and more regulates the arrangements of society. Thus accurate method was applied to the insurance-table, which enables a man to hedge against his ugliest risks, to eliminate his chances of fire and death by betting that he shall have a new roof over his head and a provision for his widow. Of all the wonderful turns of the human mind in the course of culture, scarce any is more striking than this history of lots and dice. Who, in the middle ages, could have guessed what would be its next outcome—that magic sunk

into sport should rise again as science, and man's failure to divine the future should lead him to success in controlling it?

Already in the ancient world there appear mentions of games where the throws of lots or dice, perhaps at first merely scored with counters on a board, give the excitement of chance to a game which is partly a draught-game, the player being allowed to judge with which pieces he will move his allotted number. In England this group of games is represented by *backgammon*. When Greek writers mention dice-playing, they no doubt often mean some game of this class, for at mere hazard the Persian queen-mother could not have played her game carefully, as Plutarch says she did, nor would there have been any sense in his remark that in life, as in dicing, one must not only get good throws, but know how to use them. The Roman game of the twelve lines (*duodecim scripta*) so nearly corresponded with our trictrac or backgammon, that M. Becq de Fouquières, in his "Jeux des Anciens," works out on the ordinary backgammon-board the problem of the Emperor Zeno that has vexed the soul of many a critic. All these games, however, are played with dice, and as there exist other games of like principle where lots are thrown instead of dice, it may perhaps be inferred that such ruder and clumsier lot-backgammon was the earlier, and dice-backgammon a later improvement upon it. Of course, things may have happened the opposite way. Lot-backgammon is still played in the East in more than one form. The Arabic-speaking peoples call it *tab*, or game, and play it with an oblong board or rows of holes in the ground, with bits of brick and stone for draughts of the two colors, and for lots four palm-stick slips with a black and white side. In this low variety of lot-backgammon, the object is not to get one's own men home, but to take all the adversary's. The best representative of this group of games is the Hindoo *pachisi*, which belongs to a series ancient in India. It is played on a cross-shaped board or embroidered cloth, up and down the arms of which the pieces move and take, in somewhat the manner of backgammon, till they get back to the central home. The men move by the throws of a number of cowries, of which the better throws not only score high, but entitle the player to a new throw, which corresponds to our rule of doubles giving a double move at backgammon. The game of pachisi has great vogue in Asia, extending into the far East, where it is played with flat tamarind-seeds as lots. It even appears to have found its way still farther eastward, into America, forming a link in the chain of evidence of an Asiatic element in the civilization of the Aztecs.* For the early Spanish-American writers describe, as played at the court of Montezuma, a game called *patolli*, played after the manner of their European tables or backgammon, but on a mat with a diagram like a + or Greek cross, full of squares on which the different-colored stones or pieces of the

* See the author's paper in the "Journal of the Anthropological Institute," November, 1878.

players were moved according to the throws of a number of marked beans. Without the board and pieces, the mere throwing hazards with the beans or lots, to bet on the winning throws, furnishes the North American tribes with their favorite means of gambling, the game of plum-stones, game of the bowl, etc.

It is a curious inquiry what led people to the by no means obvious idea of finding sport in placing stones or pieces on a diagram and moving them by rule. One hint as to how this may have come about is found in the men at backgammon acting as though they were "counters" counting up the throws. The word *abax*, or *abacus*, is used both for the reckoning-board with its counters and the play-board with its pieces, whence a plausible guess has been made that playing on the ruled board came from a sportive use of the serious counting instrument. The other hint is that board-games, from the rudest up to chess, are so generally of the nature of *Kriegspiel*, or war-game, the men marching on the field to unite their forces or capture their enemies, that this notion of mimic war may have been the very key to their invention. Still these guesses are far from sufficient, and the origin of board-games is still among the anthropologist's unanswered riddles. The simpler board-games of skill, that is, without lots or dice, and played by successive moves or draws of the pieces, may be classed accordingly as games of *draughts*, this term including a number of different games, ancient and modern.

The ancient Egyptians were eager draught-players; but though we have many pictures, and even the actual boards and men used, it is not clear exactly how any of their games were played. Ingenuity and good heavy erudition have been misspent by scholars in trying to reconstruct ancient games without the necessary data, and I shall not add here another guess as to the rules of the draughts with which Penelope's suitors delighted their souls as they sat at the palace gates on the hides of the oxen they had slaughtered; nor will I discuss the various theories as to what the "sacred line" was in the Greek game of the "five lines," mentioned by Sophocles. It will be more to the purpose to point out that games worth keeping up hardly die out, so that among existing sports are probably represented, with more or less variation, the best games of the ancients. On looking into the mentions of the famous Greek draught-game of *plinthion*, or *polis*, it appears that the numerous pieces, or "dogs," half of them of one color and half of the other, were moved on the squares of the board, the game being for two of the same color to get one of the other color between them, and so take him. The attempt to reason out from this the exact rules of the classic game has not answered. But on looking, instead of arguing, I find that a game just fitting the description still actually exists. The donkey-boys of Cairo play it in the dust with "dogs," which are bits of stone and red brick, and the guides have scratched its *sîga*, or diagram, on the top of the great pyramid. If it

was not there before, it would have come with Alexander to Alexandria, and has seemingly gone on unchanged since. There is an account of it in Lane's "Modern Egyptians," and any one interested in games will find it worth trying with draughts on a cardboard square. One kind of the Roman game of *latrunculi* was closely related to this, as appears from such passages as Ovid's "cum medius gemino calculus hoste perit," referring to the stone being taken between two enemies. The poet mentions, a few lines further on, the little table with its three stones, where the game is "continuasse suos," to get your men in a line, which is, of course, our own childish game of *tit-tat-to*. This case of the permanence of an ancient game was long ago recognized by Hyde in his treatise, "De Ludis Orientalibus." It is the simplest form of the group known to us as *mill*, *merelles*, *morris*, played by children all the way across from Shetland to Singapore. Among the varieties of draught-games played in the world, one of the most elaborate is the Chinese *wei-chi*, or game of circumvention, the honored pastime of the learned classes. Here one object is to take your enemy by surrounding him with four of your own men, so as to make what is called an "eye," which looks as though the game belonged historically to the same group as the simpler classic draughts, where the man is taken between two adversaries. In modern Europe the older games of this class have been superseded by one on a different principle. The history of what we now call *draughts* is disclosed by the French dictionary, which shows how the men used to be called *pions*, or pawns, till they reached the other side of the board, then becoming *dames*, or queens. Thus the modern game of draughts is recognized as being, in fact, a low variety of chess, in which the pieces are all pawns, turned into queens in chess-fashion when they gain the adversary's line. The earliest plain accounts of the game are in Spanish books of the middle ages, and the theory of its development through the mediæval chess problems will be found worked out by the best authority on chess, Dr. A. van der Linde, in his "Geschichte des Schachspiels."

The group of games represented by the Hindoo *tiger-and-cows*, our *fox-and-geese*, shows in a simple way the new situations that arise in board-games when the men are no longer all alike, but have different powers, or moves. Isidore of Seville (about A. D. 600) mentions, under the name of *latrunculi*, a game played with pieces of which some were common soldiers (*ordinarii*), marching step by step, while others were wanderers (*vagi*). It seems clear that the notions of a kriegspiel, or war-game, and of pieces with different powers moving on the checker-board, were familiar in the civilized world at the time when, in the eighth century or earlier, some inventive Hindoo may have given them a more perfect organization by setting on the board two whole opposing armies, each complete in the four forces, foot, horse, elephants, and chariots, from which an Indian army is called in Sanskrit *chaturanga*,

or "four-bodied." The game thus devised was itself called *chaturanga*, for when it passed into Persia it carried with it its Indian name in the form *shatranj*, still retained there, though lost by other nations who received the game from Persia, and named it from the Persian name of the principal piece, the *shah*, or king, whence *schach, eschecs, chess*. According to this simple theory, which seems to have the best evidence, chess is a late and high development arising out of the ancient draught-games. But there is another theory maintained by Professor Duncan Forbes in his "History of Chess," and prominent in one at least of our chess handbooks, which practically amounts to saying that chess is derived from backgammon. It is argued that the original game was the Indian fourfold-chess, played with four half-sets of men, black, red, green, and yellow, ranged on the four sides of the board, the moves of the pieces being regulated by the throws of dice; that in course of time the dice were given up, and each two allied half-sets of men coalesced into one whole set, one of the two kings sinking to the position of minister, or queen. Now, this fourfold Indian dice-chess is undoubtedly a real game, but the mentions of it are modern, whereas history records the spread of chess proper over the East as early as the tenth century. In the most advanced Indian form of *pachisi*, called *chupur*, there are not only the four sets of different-colored men, but the very same stick-dice that are used in the dice-chess, which looks as though this latter game, far from being the original form of chess, were an absurd modern hybrid resulting from the attempt to play backgammon with chess-men. This is Dr. van der Linde's opinion, readers of whose book will find it supported by more technical points, while they will be amused with the author's zeal in belaboring his adversary Forbes, which reminds one of the legends of mediæval chess-players, where the match naturally concludes by one banging the other about the head with the board. It is needless to describe here the well-known points of difference between the Indo-Persian and the modern European chess. On the whole, the Indian game has substantially held its own, while numberless attempts to develop it into philosophers' chess, military tactics, etc., have been tried and failed, bringing, as they always do, too much instructive detail into the plan which in ancient India was shaped so judiciously between sport and science.

In this survey of games, I have confined myself to such as offered subjects for definite remark, the many not touched on including cards, of which the precise history is still obscure. Of the conclusions brought forward, most are no doubt imperfect, and some may be wrong, but it seemed best to bring them forward for the purpose of giving the subject publicity, with a view to inducing travelers and others to draw up minutely accurate accounts of all undescribed games they notice. In Cook's "Third Voyage" it is mentioned that the Sandwich Islanders played a game like draughts with black and white pebbles on a board of fourteen by seventeen squares. Had the explorers spent an

hour in learning it, we should perhaps have known whether it was the Chinese or the Malay game, or what it was; and this might have been the very clew, lost to native memory, to the connection of the Polynesians with a higher Asiatic culture in ages before a European ship had come within their coral reefs.

It remains to call attention to a point which this research into the development of games brings strongly into view. In the study of civilization, as of so many other branches of natural history, a theory of gradual evolution proves itself a trustworthy guide. But it will not do to assume that culture must always come on by regular, unvarying progress. That, on the contrary, the lines of change may be extremely circuitous, the history of games affords instructive proofs. Looking over a playground wall at a game of hockey, one might easily fancy the simple line of improvement to have been that the modern schoolboy took to using a curved stick to drive the ball with, instead of hurling it with his hands as he would have done if he had been a young Athenian of B. C. 500. But now it appears that the line of progress was by no means so simple and straight, if we have to go round by Persia, and bring in the game of polo as an intermediate stage. If, comparing Greek draughts and English draughts, we were to jump to the conclusion that the one was simply a further development of the other, this would be wrong, for the real course appears to have been that some old draught-game rose into chess, and then again a lowered form of chess came down to become a new game of draughts. We may depend upon it that the great world-game of evolution is not played only by pawns moving straight on, one square before another, but that long-stretching moves of pieces in all directions bring on new situations, not readily foreseen by minds that find it hard to see six moves ahead upon a chess-board.—*Fortnightly Review.*

WHALES AND THEIR NEIGHBORS.

By Dr. ANDREW WILSON.

THE medical student, who, in answer to an examiner anxious to ascertain the exact amount of the lad's knowledge concerning fishes, replied that "he knew them all from the limpet to the whale," must indeed be credited with a larger share of candor than of zoölogical science. The limpet is a shell "fish" by courtesy at the best, but the whale, public opinion notwithstanding, is not a fish in any sense of the term. The most that can be said of the whale in this respect is that it is fish-like; and, admitting that appearances in zoölogical study are as deceptive as in ordinary existence, it behooves us to be cautious in accepting outward resemblances as indicative of real and

veritable affinity. A popular lesson in natural history, then, teaches us that a whale is a quadruped—that is, apart from the mere etymology of the word, it belongs to the quadruped class. It possesses but two legs, or rather "arms," it is true, and these members do not resemble limbs. But it is a quadruped notwithstanding its deficiencies in this respect; and it agrees in all the characters which are found to distinguish the class to which man himself belongs, that of the Mammalia. These characters it may be advantageous very briefly to detail, by way of preliminary to the general study of whales and their nearest relations. Thus, firstly, they are warm-blooded animals, a statement which must be taken as meaning that their blood is of a temperature considerably higher than that of the medium in which they live. The fish, on the other hand, is a cold-blooded creature. Its temperature is only slightly higher than that of the surrounding water, and in this respect it agrees with all invertebrate animals and with the frogs and reptiles of its own sub-kingdom. Next in order may be noticed the agreement of the whale with the quadruped in the matter of body-covering. The covering of the latter consists of hairs. Although the body of the whale can not be described, by any stretch of the imagination, as having hair, the presence of a few bristles around the mouth-extremity sufficiently indicates the nature of its outer garment; while, before birth, the body-covering in some whales is tolerably plentiful, but is soon shed, leaving the hide thick, shining, and hairless. The microscopist might inform us that the blood of the whale presents the same characters as that of other mammals, and possesses red corpuscles or colored bodies, which, unlike those of the fish, reptile, and bird, have no central particle or "nucleus." And while the heart of the fish is a comparatively simple engine of propulsion, consisting of two contractile chambers or cavities, the whale's heart will be found like that of man and other quadrupeds in all essential details of its structure. It is thus a four-chambered organ doing double duty, in that it sends blood not only through the system, but also to the lungs for purification.

The mention of lungs as the breathing organs of whales at once introduces us to a new field of inquiry concerning the habits and life of the aquatic monsters. A popular notion exists that of necessity a water-living animal must be a *water-breather*. The idea of fish existence and of the manner in which fishes breathe evidently reigns paramount in the present case. That an animal may be completely aquatic in its habits, and yet breathe air directly from the atmosphere, and after a like procedure to that witnessed in human respiration, is a notable fact. A water-newt, despite its aquatic habits, ascends periodically to the surface of the water to breathe; and seals, walruses, and whales agree in that they are truly lung-breathers, and possess gills at no period of their existence. True, a gill differs from a lung only in that it is capable of exposing the blood circulating through it to the

air which is entangled or mechanically suspended in the water. Atmospheric air containing the vitalizing oxygen for the renewal and purification of the blood is the great desideratum on the part of all animals, high and low alike. And the gill and lung, therefore, differ simply in the manner and method in which the blood in each is brought in contact with the air, and not in the essential details of their work. The whales are known to "blow," and the act of "blowing" is simply the act of breathing—to be more particularly noticed hereafter. Thus, a whale or seal would be drowned as certainly as an ordinary quadruped would be asphyxiated, were its periodical access to the atmosphere prevented; and the curious fact may here be mentioned that there are also certain abnormal living fishes—notably the climbing perch and *ophiocephali* of India—which, to use the words of a writer, are as easily drowned as dogs when denied access to the air. There is little need to particularize any of the remaining characters which demonstrate the whale's relationship to mammals, and its difference in structural points from the fishes. The young whale is thus not merely born alive, but is nourished by means of the milk-secretion of the parent, and this last evidence of direct connection with higher animals might of itself be deemed a crucial test of the place and rank of the whales in the animal series.

But, granting that in the whales we meet with true quadrupeds, it may be well to indicate the chief points in which they differ from their mammalian brethren at large. It may be admitted, at the outset, that they present us with a very distinct modification of the quadruped type. Their adaptation to a water-life is so complete, in truth, that it has destroyed to a large extent the outward and visible signs of their relationship with mammals. The body is thoroughly fish-like and tapers toward the tail, where we meet with a tail-fin, which, however, is set right across the body, and not vertically as in the fishes. This latter difference, indeed, is a very prominent feature in whale-structure. The limbs, as already remarked, are represented by the two fore-limbs alone. No trace of hinder-extremities is to be perceived externally, and the anatomical investigation of the skeleton reveals at the best the merest rudiments of haunch-bones and of hind-limbs in certain whales, of which the well-known Greenland whale may be cited as an example. A distinct character of the whales has been found by naturalists of all periods in the "blowholes" or apertures through which the whale is popularly supposed to "spout." Thus we find on the upper surface of the head of a Greenland whale a couple of these "blowholes," or "spiracles," as they are also called. These apertures exist on the front of the snout in the sperm whales, while in the porpoises, dolphins, and their neighbors the blowhole is single, of crescentic shape, and placed on the top of the head. It requires but little exercise of anatomical skill to identify the "blowholes" of the whales with the nostrils of other animals; and it becomes an interest-

ing matter to trace the adaptation of the nostrils to the aquatic life and breathing habits of these animals.

There are natural history text-books still extant in which a very familiar error regarding the "blowing" of the whales is propagated—an error which, like many other delusions of popular kind, has become so fossilized, so to speak, that it is difficult to convince believers of its falsity. A manual of natural history, of no ancient date, lies before me as I write, and when I turn to the section which treats of the whales, I find an illustration of a Greenland whale, which is represented as lying high and dry on the beach, but which, despite its stranded state, appears in the act of vigorously puffing streams of water from the blowholes on the top of its head. To say the least of it, such an illustration is simply fictitious, and might safely be discarded as of purely inventive kind, were it only from the fact of its supposing a whale to be provided with some mysterious reservoir of water from which it could eject copious streams, even when removed from the sea. The common notion regarding the "blowing" of the whale appears to be that which credits the animal with inhaling large quantities of water into its mouth, presumably in the act of nutrition. This water was then said to escape into the nostrils and to be ejected therefrom in the act of blowing. The behavior of a whale in the open sea at first sight favors this apparently simple explanation. Careering along in the full exercise of its mighty powers, the huge body is seen to dive and to reappear some distance off at the surface, discharging from its nostrils a shower of water and spray. The observation is correct enough as it stands, but the interpretation of the phenomena is erroneous. Apart from the anatomical difficulties in the way of explaining how water from the mouth could escape in such large quantities, and so persistently into the nostrils, there is not merely an utter want of purpose in this view of the act of "spouting," but we have also to consider that this act would materially interfere with the breathing of the animal. Hence a more rational explanation of what is implied in the "blowing" of the whales rests on the simple assertion that the water and spray do not in reality proceed from the blowhole, but consist of water forced upward into the air by the expiratory effort of the animal. The whale begins the expiratory or "breathing-out" action of its lungs just before reaching the surface of the water, and the warm expired air therefore carries up with it the water lying above the head and blowholes of the ascending animal. That this view is correct is rendered highly probable, not merely by the observation of the breathing of young whales and porpoises kept in confinement, but also by the fact that the last portion of the "blow" consists of a white silvery spray or vapor, formed by the rapid condensation of the warm air from the lungs as it comes in contact with the colder atmosphere. The water received into the mouth escapes at the sides of the mouth, and does not enter the nostrils at all.

The furnishings of the mouth of the whales include sundry remarkable structures peculiar to a certain family circle of these animals. Such are the "whalebone"-plates, furnishing a substance familiarly spoken of by everybody, but exemplifying at the same time a kind of material regarding the origin of which a tacit ignorance, sanctioned by the stolid indifference of many years' standing, commonly prevails. Whalebone, or "baleen," is a commodity occurring in one group of these animals only, this group being that of the whalebone whales (*Balænidæ*), of which the Greenland or Right whale (*Balæna mysticetus*) is the most noteworthy example. From this whale the whalebone of commerce is derived; other and nearly related species—such as the Rorquals and Furrowed whales—possessing the whalebone-plates in a comparatively rudimentary state. The baleen occurs in the mouth of these whales, and is disposed in a curious fashion. It exists in the form of flat plates of triangular shape, each plate being fixed by its base in the palate. The inner side, or that next the center of the mouth, is strongly fringed by frayed-out whalebone fibers, the outer edge of each plate being straight. A double row of these triangular plates of baleen depends in the form of two great fringes from the palate of the whale; and it would appear that each baleen-plate is in reality a compound structure, being composed of several smaller plates closely united. The largest plates lie to the outer side of the series, and in a full-grown whale may measure from eight to fourteen feet in length, and as many as 250 or 300 plates may exist on each side of the palate.

The nature of these curious organs forms an appropriate subject of inquiry. It is exceedingly rare in nature to find an animal provided with organs or structures which have no affinity with organs in other and related animals. On the contrary, the principle of likeness or "homology" teaches us that the most unwonted and curious structures in animal existence are for the most part modifications of common organs, or at any rate of parts which are represented under varying forms and guises in other animals. By aid of such a principle we discover that the fore-limb of a horse, the wing of a bird, and the paddle of a whale are essentially similar in fundamental structure, and in turn agree in all necessary details with the arm of man. Through the deductions of this science of tracing likenesses and correspondences between the organs of different animals, the zoölogist has been taught that the "air-bladder" or "sound" of the fish is the forerunner of the lung of higher animals—an inference proved by the fact that in some fishes, such as the curious Lepidosirens or "mud-fishes" of Africa and South America, the air-bladder actually becomes lung-like, not merely in form but in function also. By means of this useful guide to the mysteries of animal structure, we note that the bony box in which the body of the tortoise or turtle is contained is formed by no new elements or parts, but consists chiefly of the greatly modified backbone and of the ribs

and scales of these animals. To what conclusion, then, does this same principle lead us respecting the nature of the baleen-plates in the mouth of the Greenland whale and its allies? To a sufficiently certain, but at the same time startling thought, is the reply of the comparative anatomist.

If we examine the structure of the human mouth, or that of animals allied to man, we find that cavity to be lined by a delicate layer named *epithelium*. This epithelium consists really of a modification of the upper layer of the skin, and we see this modification familiarly in the difference between the skin of the face and the layer which is infolded to form the covering of the lips and the lining membrane of the mouth. No tissue is more familiar to the student of physiology than epithelium, composed as it is of *epithelial cells* or microscopic elements, which in one form or another are found in almost every important tissue of the body. The epithelium is a delicate tissue, as usually seen in man and vertebrate animals; but in some instances it becomes hardened by the development of horny matter, and may then appear as a tissue of tolerably solid consistence. In the mouth of a cow or sheep, the epithelium of part of the upper jaw is found hardened and callous, and there forms a horny pad against which the front teeth of the lower jaw may bite in the act of mastication. It is exactly this epithelial layer, then, which becomes enormously developed in the whalebone whales to form the baleen-plates just described. That this is actually the case is ascertained by the development of the baleen-plates, as well as by their situation and relations to the gum and palate. And the recital becomes the more astonishing when we consider that, from cells of microscopic size in other animals, structures of enormous extent may be developed in the whales. The baleen-plates possess a highly important office. They constitute a kind of huge strainer or sieve, the possession of which enables the whale to obtain its food in a convenient fashion. Whether or not Biblical scholars and commentators agree in regarding the "great fish" which wrought calamity to the prophet Jonah as a special creation, and as an entirely different animal from the whale of to-day, the plain fact remains that a whale has a gullet of relatively small size when compared with the bulk of the animal. Fortunately, however, the faith of rational mankind is not pinned to literal interpretation of the untoward incident chronicled in Jonah, and, whale or no whale, it is curious to learn that the largest of animals may in a manner be said to feed on some of the most diminutive of its fellows. In the far north, and in the surface-waters of the Arctic seas, myriads of minute organisms, closely allied to our whelks, and like mollusks, are found. Such are the "Sea-butterflies," or *Pteropoda* of the naturalist: little delicate creatures which paddle their way through the yielding waters by aid of the wing-like appendages springing from the sides of the head and neck. These organisms are drawn into the mouth of the Greenland whale in veritable shoals, and as the

literal flood of waters streams out of the sides of the mouth, the "sea-butterflies" are strained off therefrom, the savory morsels being retained by the fringed edges of the baleen-plates, and thereafter duly swallowed as food.

An interesting speculation yet remains, however, regarding the origin and first development of these peculiar whalebone-structures. Advocates of the doctrine which assumes that animal forms and their belongings arise by gradual modifications of preëxistent animals may be reasonably asked to explain the origin of the baleen-plates of the whales. Let us briefly hear what Mr. Darwin, as the spokesman of the party, has to say in reply to such an inquiry. Quoting a remark of an opponent regarding the whalebone, Mr. Darwin says, if the baleen "'had once attained such a size and development as to be at all useful, then its preservation and augmentation within serviceable limits would be promoted by natural selection alone. But how to obtain the beginning of such useful development?' In answer," continues Mr. Darwin (in his own words), "it may be asked, why should not the early progenitors of the whales with baleen have possessed a mouth constructed something like the lamellated beak of a duck. Ducks, like whales, subsist by sifting the mud and water; and the family (of ducks) has sometimes been called *Criblatores*, or sifters." Mr. Darwin's reference to the duck's bill is peculiarly happy. The edges of the beak in these birds are fringed with a beautiful series of horny plates named *lamellæ*, which serve as a straining apparatus as the birds grope for their food amid the mud of ponds and rivers. These plates are richly supplied with nervous filaments, and doubtless also some as organs of touch. Mr. Darwin is careful to add that he hopes he may not "be misconstrued into saying that the progenitors of whales did actually possess mouths lamellated like the beak of a duck. I only wish to show," he continues, "that this is not incredible, and that the immense plates of baleen in the Greenland whale might have been developed from such lamellæ by finely graduated steps, *each of service to its possessor*."

In these last words, which we have italicized, lies the strength of Mr. Darwin's hypothesis. Nature will preserve and develop useful structures alone, and will leave the useless and unneeded to perish and decay. This, indeed, is the keynote of natural selection. Mr. Darwin next proceeds to examine in detail the plates and lamellæ in the bill of a shoveler duck. He describes the horny plates, one hundred and eighty-eight in number, which "arise from the palate, and are attached by flexible membrane to the sides of the mandible." He further notes that these plates "in several respects resemble the plates of baleen in the mouth of a whale." If the head of a shoveler duck were made as long as the head of a species of whale in which the baleen-plates are only nine inches long, the duck's lamellæ would be six inches in length. The head of the shoveler is about one eighteenth

of the length of the head of such a whale, so that the difference in size between the duck's lamellæ and the imperfect baleen-plates of this whale is not markedly disproportionate, after all. After the examination of the beaks of various species of swimming-birds, Mr. Darwin arrives at the conclusion that "a member of the duck family with a beak constructed like that of the common goose, and adapted solely for grazing, or even a member with a beak having less well-developed lamellæ, might be converted by small changes into a species like the Egyptian goose (which partly grazes and partly sifts mud)—this into one like the common duck—and, lastly, into one like the shoveler, provided with a beak almost exclusively adapted for sifting the water; for this bird could hardly use any part of its beak, except the hooked tip for seizing or tearing solid food. The beak of a goose, as I may add," says Mr. Darwin, "might also be converted by small changes into one provided with prominent recurved teeth, like those of the Merganser (a member of the same family), serving for the widely different purpose of securing live fish."

Mr. Darwin next endeavors to apply the moral of this interesting sketch of probable modification of the bills of ducks to the case of the whales. If the stages of modification in these animals are hypothetically so clear, may not the case of the whalebone-bearing whales be susceptible of like explanation? A certain whale (*Hyperoödon*) belonging to a small group known popularly as the "beaked whales," from the possession of a prominent beak or snout, has no true teeth, but bears rough, unequal knobs of horny nature in its palate. Here, therefore, is a beginning for the work of selection and development. Granted that these horny processes were useful to the animal in the prehension and tearing of food, then their subsequent development into more efficient organs is a warrantable inference if the order of living nature teaches us aright. From rudimentary knobs, a further stage of development would lead to an increase in which they may have attained the size of the lamellæ of an Egyptian goose, which, as already remarked, are adapted both for sifting mud and for seizing food. A stage beyond, and we reach the shoveler's condition, "in which the lamellæ would be two thirds of the length of the plates of baleen," in a species of whalebone whale (*Balænoptera*) possessing a slight development of these organs. And from this point, the further gradations leading onward to the enormous developments seen in the Greenland whale itself, are easily enough traced. Hypothetically, therefore, the path of development is clear enough. Even if it be remarked that the matter is entirely one of theory, not likely to be ever partly verified, far less proved at all, we may retort that any other explanation of the development of the organs of living beings, and of living beings themselves, must also be theoretical in its nature and as insusceptible of direct proof as are Mr. Darwin's ideas. But the thoughtful mind must select a side, and choose between probabilities;

and it is not too much to say that toward the side of the idea which advocates gradual modification and selection as the rule of life and nature, every unbiased student of natural science will by sheer force of circumstances be led to turn.

The whalebone whales have no teeth, although the sperm whale possesses teeth in the lower jaw; but thereby—that is, as regards the teeth of whales at large—hangs a tale of some importance, and to which our attention may be briefly directed. Among the paradoxes of living nature, no circumstances present more curious features than those relating to the so-called "rudimentary organs" of animals and plants; the subject of these organs, and the lessons they are well calculated to teach, having been recently treated at some length in these pages. Now, the whales furnish several notable examples of the anomalies which apparently beset the pathways of development in animals. The adult whalebone whale is toothless, as has just been remarked; and this fact becomes more than usually interesting when taken in connection with another, namely, that the young whale before birth possesses teeth, which are shed or absorbed, and in consequence disappear before it is born. These teeth never "cut the gum," and the upper jaw of the sperm whale presents us with a like phenomenon for consideration. Nor are the whales peculiar in this respect. The upper jaw of ruminant animals has no front teeth—as may be seen by looking at the mouth of a cow or sheep—yet the calf may possess rudimentary teeth in this situation, these teeth also disappearing before birth. Now, what meaning, it may be asked, are we to attach to such phases of development? Will any considerations regarding the necessity for preserving the "symmetry," or "type," of the animal form aid us here; or will the old and overstrained argument from design enable us to comprehend why nature should provide a whale or a calf with teeth for which there is no conceivable use? The only satisfying explanation which may be given of such anomalies may be couched in Darwin's own words. The embryonic teeth of the whales have a reference "to a former state of things." They have been retained by the power of inheritance. They are the ignoble remnants and descendants of teeth which once were powerful enough, and of organs with which the mighty tenants of the seas and oceans of the past may have waged war on their neighbors. Again, the laws and ideas of development stand out in bold relief as supplying the key to the enigma. Adopt the theory that "things are now just as they always were," and what can we say of rudimentary teeth, save that Nature is a blunderer at best, and that she exhibits a lavish waste of power in supplying animals with useless structures? But choose the hypothesis of development, and we may see in the embryo-teeth the representatives of teeth which in the ancestors of our whales served all the purposes of such organs. Admit that, through disuse, they have become abortive and useless; and we may then, with some de-

gree of satisfaction, explain their true nature. To use Darwin's simile, such rudiments are like letters in a word which have become obsolete in pronunciation, but which are retained in the spelling, and serve as a clew to the derivation of the word.

In the course of these remarks allusion has been made to more than one species of whale, and it may, therefore, form a study of some interest if we endeavor, shortly, to gain an idea of the general relationship and degrees of affinity of the various members of this curious family-circle. The whale order includes several of the divisions to which the zoölogist applies the name of "families," indicating, by this latter term, a close affinity in form, structure, and habits between the members of each group. First in importance among these families comes that of the whalebone whales (*Balænidæ*). Here we find family characters in a head disproportionately large when compared with the body as a whole, while the muzzle is sloping, and of rounded conformation. Teeth are absent, as we have seen; whalebone-plates fringe the palate; and the "blowhole" is single, and exists on the top of the head. Such are the family characters in which the Greenland or Right whale and the still larger Rorqual participate along with the "finner" whales and "humpbacked" whales. There is no back fin in the Greenland whale, but the Rorquals and their neighbors possess this appendage. It need hardly be said that, commercially, the former animal is of most importance; while the Rorquals are famed as the largest of the whales. Specimens of the Rorqual have been captured exceeding a hundred feet in length. One specimen, measuring ninety-five feet in length, weighed 245 tons. Next in importance to the Greenland whale and its relatives may be mentioned the family *Physeteridæ*, of which the sperm whale is the representative form. Here, the head reaches literally enormous proportions, and may make up fully one third of the body. A blunt, square muzzle; a lower jaw armed with teeth; an absence of baleen-plates, and a front blowhole—such are the characters of the sperm whale, which gives sperm-oil to the merchant, and spermaceti and ambergris to the man of drugs. A whole host of "small fry" present themselves as near relations of the whales, in the shape of the dolphins, porpoises, grampus, "bottle-noses," and other animals, including the famous narwhal, or sea-unicorn, possessing the longest tooth in the world in the shape of a spiral ivory pole, of some eight or ten feet in length. Here also the *Beluga catodon*, or "white whale," finds a zoölogical home, this latter form being the species of which more than one specimen has been recently exhibited in London. The beluga, being a member of the dolphin family, is a "whale" by courtesy only. Like the other members of this group, its blowhole is single and crescentic in shape, and both jaws are well provided with teeth. But the beluga, unlike the dolphins and porpoises, has no back fin, and its muzzle is blunt. This animal, however, is still certainly "very like a whale" in its general

shape and aspect. Its creamy, white skin is certainly a peculiar feature; but the broad, horizontal tail-fin is well exemplified in this northern stranger, while the breathing habits of its group may also be studied superficially but satisfactorily on the specimen in question. The beluga inhabits the North American coast, at the mouths of the rivers on the Labrador and Hudson's Bay coast, while it is known to penetrate even to the Arctic regions. These whales are plentiful in the Gulf of St. Lawrence in spring and summer, and appear to migrate to the west coast of Greenland in October and November. The Esquimaux regard the beluga as their special prize, and contrive, with the aptitude for design which the necessities of savage existence teach, to utilize wellnigh every portion of its frame, even to the manufacture of a kind of animal-glass from its dried and transparent internal membranes.

But little space remains in which to treat of certain near relations and somewhat interesting allies of the whales. Such are the *Manatees*, or "sea-cows," and the Dugongs, collectively named *Sirenia*, in the category of zoölogists. The origin of this latter name is attended with some degree of interest. It has been bestowed on these animals from their habit of assuming an upright or semi-erect posture in the water; their appearance in this position, and especially when viewed from a distance by the imaginative nautical mind, having doubtless laid a foundation, in fact, for the tales of "sirens" and "mermaids" anxious to lure sailors to destruction by their amatory numbers. Any one who has watched the countenance of a seal from a short distance must have been struck with the close resemblance to the human face which the countenance of these animals presents. Such a likeness is seen even to a greater degree in the sea-cows, which also possess the habit of folding their "flippers," or swimming-paddles, across their chests, and, it is said, of holding the young to the breast in the act of nutrition by aid of the paddle-like fore-limbs. If I mistake not, Captain Sowerby mentions, in an account of his voyages, that the surgeon of the ship on one occasion came to him in a state of excitement to announce that he had seen a man swimming in the water close at hand; the supposed human being proving to be a manatee, which had been, doubtless, merely exercising a natural curiosity regarding the ship and its tenants.

These animals are near relatives of the whales, but differ from them, not merely in habits, but in bodily structure and conformation. They live an estuarine existence, rarely venturing out to sea. The manatees occur in the shallow waters and at the mouths of the great rivers of the Atlantic coasts of America and Africa. The dugongs inhabit the shores of the Indian Ocean, and are common on certain parts of the Australian coasts. There are only two living genera—the manatees and dugongs—of these animals; a third, the *Rhytina Stelleri*, having, like the famous Dodo, become extinct through its

wholesale slaughter by man, in 1768, just twenty-seven years after it was first discovered by the voyager Behring on a small island lying off the Kamtchatkan coast. The Rhytina was a great unwieldy animal of some twenty-seven feet in length, and about twenty feet in circumference. It fell a ready prey to Behring and his crew, who were located on the island for several months; the work of extermination being duly completed by subsequent voyagers who visited the island. The manatees are no strangers to London, since in 1875 one of these animals was to be seen disporting itself in the seal-tank in the gardens of the Zoölogical Society at Regent's Park. This specimen, a female of immature age, was brought from the Demerara coast, and was the first living specimen which had been brought to England, although attempts had been made in 1866 to procure these animals for the gardens at Regent's Park, one specimen, indeed, dying just before reaching Southampton. A member of the Manatee group, obtained from Trinidad, was recently exhibited in London, and the public, interested in the curious in zoölogy, were thus enabled to interview a living member of the Siren group, while comparative anatomists, in their turn, have been afforded a rich treat from the fate which awaits rare and common specimens having, as we write, overtaken the illustrious visitor in question.

The manatees and dugongs possess bodies which, as regards their shape, may be described each as a great barrel "long drawn out." No hinder limbs are developed, this latter peculiarity distinguishing them from the seals, and relating them to the whales. The hide is very tough, sparsely covered with hair, and most nearly resembles that of the hippopotamus. The "flippers," or paddle-like limbs, are placed far forward on the body, and on the edge of the paddle rudimentary nails are developed; while concealed beneath the skin of the paddle we find the complete skeleton of an arm or fore-limb. The tail is broad, horizontally flattened, like that of the whales, and forms an effective propeller. These animals are vegetable feeders, the Zoölogical Society's specimen having exhibited a strong partiality for lettuce and vegetable-marrow. In a state of nature the sea-cows crop the marine vegetation which fringes their native shores. The remaining outward features of interest in these creatures may be summed up by saying that no back fins are developed; that the eyes are very small and inconspicuous; and that, although the anterior nostrils are never used as "blowholes," they can be closed at will like the nostrils of the seals—a faculty of needful kind in aquatic animals. To the technical anatomist, the sea-cows present strong points of resemblance to some of the hoofed quadrupeds. The anatomical examination of these animals has shown that their peculiarities are not limited to their outward appearance and habits. It is not generally known, for example, that the neck of the vast majority of mammals consists of seven vertebræ or segments of the spine. Man thus possesses this number in

common with the giraffe, the elongation of whose neck is produced not by introduction of new vertebræ, but by the great development of the normal number, seven. The manatees, however, present a very remarkable exception to this most general of rules, in that they possess only six vertebræ in their necks. The only other exceptions to the rule of seven, as the normal number of neck-vertebræ in quadrupeds, are found in one species of sloth which has six vertebræ like the manatee, and in another kind of sloth which possesses nine. Then, also, the manatees possess a heart of very curious conformation, its apex or tip being widely cleft or divided—a feature much more plainly marked in these animals than in the elephants and seals, whose hearts, anatomically speaking, are also divided. The manatees possess well-developed molars or grinding teeth, but have no front teeth in the adult state. Like the whalebone whale, however, the young manatee has front teeth, these again disappearing before birth, and presenting us once more with examples of rudimentary organs which possess a reference "to a former state of things."

What evidence is at hand respecting the remote ancestors of the whales and their neighbors? is a question which may form a fitting conclusion to these brief details of the family history of the group. The geological evidence shows us that the whales are comparatively "recent" forms, speaking geologically, and dealing—notwithstanding the word "recent"—with very remote and immense periods of time. Among the oldest fossil whales we find one form in particular (*Zeuglodon*) which had teeth of larger kind than are possessed by any living whale, this creature being by some authorities regarded as linking the whales with the seals. The fossil remains of Zeuglodon and its neighbors first occur in Eocene rocks—that is, in the oldest formations of the Tertiary series, and in rocks of relatively "recent" nature. These remarkable creatures were as gigantic as their living representatives. One species is known to have attained a length of seventy feet. Their remains are of such frequent occurrence in the "Jackson Beds" of the United States, that Professor Dana remarks: "The large vertebræ, some of them a foot and a half long and a foot in diameter, were formerly so abundant over the country in Alabama, that they were used for making walls, or were burned to rid the fields of them." The teeth of this curious monster of the vasty Eocene deep were of two kinds, and included front teeth of conical shape, and grinders or molars; the latter exhibiting a striking peculiarity in that they were formed each of two halves, or teeth united by their crowns, but separated at their roots. Zeuglodon appears to connect the whales and their neighbors with the seals and walruses, and thus in one sense may be said to constitute, if not a "missing link," at least an intermediate form of anomalous kind, when viewed relatively to the existing cetaceans. According to the geological evidence at hand, we may assume that the modifications which have produced the existing whales and

their neighbors are of comparatively recent date, and that their adaptation to an aquatic life is a thing but of yesterday when compared with the duration of previous æons in the history of our globe.

Gentleman's Magazine.

A PROBLEM IN HUMAN EVOLUTION.

By Professor GRANT ALLEN.

"HARDLY any view advanced in this work," says the illustrious author of the "Descent of Man," "has met with so much disfavor as the explanation of the loss of hair in mankind through sexual selection." Indeed, the friends and foes of Mr. Darwin's great theories have been equally ready, the one party to disclaim and the other party to ridicule the account which the founder of modern philosophic biology has given of the process whereby man, as he supposes, gradually lost the common hairy covering of other mammalia. Mr. Wallace, with all his ability and ingenuity, finds it necessary to call in the aid of a *deus ex machina* to explain the absence of so useful and desirable an adjunct; for he believes that natural selection could never have produced this result, and he therefore feels compelled to put it off upon "some intelligent power," since he denies altogether the existence of sexual selection as a *vera causa*. Mr. J. J. Murphy, in his recently published revision of "Habit and Intelligence," has taken up the same ground with a more directly hostile intent; and Spengel has also forcibly given expression to his dissent on the plea of inadequate evidence for the supposed preference. It seems highly desirable, therefore, to prop up Mr. Darwin's theory by any external supports which observation or analogy may suggest, and if possible to show some original groundwork in the shape of a natural tendency to hairlessness, upon which sexual selection might afterward exert itself so as to increase and accelerate the depilatory process when once set up.

The curious facts for which we have to account are something more than the mere general hairlessness of the human species. In man alone, as Mr. Wallace clearly puts the case, "the hairy covering of the body has almost totally disappeared; and, what is very remarkable, it has disappeared more completely from the back than from any other part of the body. Bearded and beardless races alike have the back smooth, and even when a considerable quantity of hair appears on the limbs and breast, the back, and especially the spinal region, is absolutely free, thus completely reversing the characteristics of all other mammalia." When we consider the comparatively helpless condition to which man has been thus reduced, as well as the almost universal human practice of substituting artificial clothing,

derived from the skins or wool of other animals, for the natural apparel which the species has so unaccountably lost, it does not seem surprising that even Mr. Wallace should be staggered by the difficulty, and should fall back upon an essentially supernatural explanation.

The great key to the whole problem lies, it would seem, in the fact thus forced upon our attention, that the back of man forms the specially hairless region of his body. Hence we must conclude that it is in all probability the first part which became entirely denuded of hair. Is there any analogy elsewhere which will enable us to explain the original loss of covering in this the normally hairiest portion of the typical mammalian body? The erect position of man appears immediately to suggest the required analogy in the most hairless region of other mammals.

Almost all animals except man habitually lie upon the under surface of the body. Hence arises a conspicuous difference between the back and the lower side. This difference is seen even in lizards, crocodiles, and other reptiles, among which, as a rule, the tegumentary modifications of the under surface are much less extended and less highly differentiated than those of the upper. It is seen among birds, which usually have the plumage far less copious on the breast than on the back. But it is most especially noticeable in mammals, which have frequently the under side almost entirely bare of hair, while the back is covered with a copious crop. Now, it would seem as though this scantiness of natural clothing on the under side were due to long-continued pressure against the ground, causing the hair to be worn away, and being hereditarily transmitted in its effects to descendants. We are, therefore, led to inquire whether all parts of the mammalian body which come into frequent contact with other objects are specially liable to lose their hair.

The answer seems to be an easy one. The soles of the feet in all mammals are quite hairless where they touch the ground. The palms of the hands in the quadrumana present the same phenomenon. The knees of those species which frequently kneel, such as camels and other ruminants, are apt to become bare and hard-skinned. The callosities of the Old-World monkeys, which sit upon their haunches, are other cases in point; but they do not occur among the more strictly arboreal quadrumana of the American Continent, nor among the lemurs, for the habits of these two classes in this respect are more similar to those of ordinary mammals. On the other hand, the New-World monkeys possess a prehensile tail, with which they frequently swing from bough to bough or lower themselves to the ground, and in these creatures, says Cuvier, "la partie prenante de la queue est nue en dessous." Wherever we find a similar organ, no matter how widely different may be the structure and genealogy of the animals which possess it, we always find the prehensile portion free from hair. This is the case with the marsupial *tarsipes*, with many rodents, and

above all with the opossum, which uses its tail quite as much as any monkey uses its hands. Accordingly, its surface is quite bare from end to end, and in some species scaly—a fact which is rendered more comprehensible when we remember that the young opossums are carried on their mother's back, and hold themselves in that position by curling their tails around hers.

A few more special facts help to bear out the same generalization. In the gorilla, according to Du Chaillu, "the skin on the back of the fingers, near the middle phalanx, is callous and very thick, which shows that the most usual mode of progression of the animal is on all-fours and resting on the knuckles." The ornithorhyncus has a flat tail, on which it leans for support, and this, says Mr. Waterhouse, "is short, depressed, and very broad, and covered with coarse hairs; these, however, are generally worn off on the under side of the tail in adult or aged individuals, probably by the friction of the ground." The toes of the very large fore-feet, used in burrowing, are also naked, as are the similar organs in the mole and many other creatures of like habit. The beaver likewise uses his tail as a support, flaps it much in the water, and is said, perhaps not quite erroneously, to employ it as a trowel in constructing his dams; and this tail is entirely devoid of hair, being covered instead with a coat of scales. We can hardly avoid being struck in this instance, as in that of some seals' and sea-lions' flappers, with the analogy of the penguin's wings, which are employed like fins in diving, and have undergone a similar transformation of their feathers into a scale-like form. In the ground-kangaroos, which use the tail as a support trailing behind them on the ground, that organ is again only slightly covered with coarse hairs, almost entirely wanting on the extremity of the under surface; but in the tree-kangaroos, which carry the tail partly erect, it assumes a bushly and ornamental appearance. Like differences occur between the rats and mice on the one hand and the squirrels on the other. In those monkeys which, like *Macacus brunneus*, sit upon their tails, that organ is also bare. To multiply further instances would only prove tedious.

Again, when we look at the only mammals besides man which have denuded themselves of their hairy covering, we find that a great majority of them are water-frequenters. The most completely aquatic mammals, like the whales, porpoises, dugongs, and manatees, though differing widely in structure, are alike in the almost total absence of hair, while the hippopotamus is likewise a smooth-skinned animal. Now, the friction of water is of course far stronger than that of air, and it would seem to have resulted in the total depilation of these very aquatic species. Other less confirmed water-haunters, such as seals and otters, have very close fur, which scarcely at all retards them in their movements when swimming. The elephant and rhinoceros are, indeed, difficult cases to explain; but of course it is not necessary

to suppose that no other cause save that which we are considering can ever produce hairlessness. It will be enough if we can show that the cause actually under examination does with reasonable certainty bring about such an effect.

If, then, the portion of animals which generally comes in contact with the ground or other external bodies acquires in this manner a hairless condition—shown alike in hands, feet, tail, and belly—what will be the result upon animals which are gradually acquiring the erect position? Of this we can obtain an almost complete series by looking first at the beaver, which rests upon its scaly tail alone; then at the baboons, which rest upon the naked callosities on their haunches; thirdly, at the gorilla; and, last of all, at mankind.

The gorilla, according to Professor Gervais, is the only mammal which agrees with man in having the hair thinner on the back, where it is partly rubbed off, than on the lower surface. This is a most important approach to a marked human peculiarity, and is well worthy of investigation. "I have myself come upon fresh traces of a gorilla's bed on several occasions," says Du Chaillu, "and could see that the male had seated himself with his back against a tree-trunk. In fact, on the back of the male gorilla there is generally a patch on which the hair is worn thin from this position, while the nest-building *Troglodytes calvus*, or bald-headed *nshiego*, which constantly sleeps under its leafy shelter on a tree-branch, has this bare place on its side, and in quite a different way. . . . When I surprised a pair of gorillas," he observes elsewhere, "the male was generally sitting down on a rock or against a tree." Once more, in a third passage he writes: "In both male and female the hair is found worn off the back; but this is only found in very old females. This is occasioned, I suppose, by their resting at night against trees, at whose base they sleep." And, when we inquire into the difference between the sexes thus disclosed, we learn that the female and young generally sleep in trees, while the male places himself in the position above described against the trunk.

The gorilla has only very partially acquired the erect position, and probably sits but little in the attitudes common to man. But if a developing anthropoid ape were to grow more and more upright in his carriage, and to lie more and more upon his back and sides, we might naturally expect that the hair upon those portions of his body would grow thinner and thinner, and that the usual characteristics of the mammalia as to dorsal and sternal pilosity would be completely reversed. This is just what has probably happened in the case of man. In proportion as he grew more erect, he must have lain less and less upon his stomach, and more and more upon his back or sides. For fully developed man, with the peculiar set of his neck, face, and limbs, it is almost impossible to rest upon his stomach. On the other hand, all savage races lie far more upon their backs than even Europeans with their sofas, couches, and easy-chairs; for the natural posi-

tion of savage man during his lazy hours is to stretch himself on the ground in the sun, with his eyes closed, and with his back propped, where possible, by a slight mound or the wall of his hut. Any person who has lived much among negroes or South Sea Islanders must have noticed how constant is this attitude with men, women, and children, at every stray idle moment.

Nor must we forget the peculiar manner in which human mothers must necessarily have carried their infants from a very early period in the development of our race. During the first eighteen months of life the human infant must always be held, or laid, more or less upon its back; and this position will probably tend to check the development of hair upon the dorsal and lateral regions.

Next, let us ask what is the actual distribution of hair upon the body of man. Omitting those portions where the ornamental use of hair has specially preserved it, the most hairy region is generally, so far as my observations go, the fore part of the leg or shin. Obviously this is a region very little likely to come in contact with external objects. On the other hand, the most absolutely hairless places are the palms of the hands and the soles of the feet, after which come the elbows, and at a long interval the knees and knuckles. The back is very hairless, and so are the haunches. But the legs are more hairy than the body, both in front and behind, though less hairy on the calf than on the shin. Now, it will be obvious that both by day and night we rest more upon our backs and haunches than upon our legs, the latter being free when we sit down on a chair or bench, doubled in front of us when we squat on the ground (the normal position of savages), and thrown about loosely when we lie down. Especially might we conclude that this would be the case with early races, unembarrassed by the weight of bedclothes. As for the arms, it is noticeable that they still retain the ordinary mammalian habit in being hairier on the back than on the front; and this also is quite in accordance with our present suggestion, because the same differentiating causes have not worked upon the arm as they work upon the back and legs. The peculiar position of the anterior extremities in man, together with the erect posture, makes the arms come much more frequently into frictional contact with the body or clothing on their inner than on their outer surface. Hair grows most abundantly where there is normally least friction, and *vice versa*. As for the hair which frequently appears upon the chest of robust Europeans and others, I shall return to that point at a later stage. It may be noted, however, that while the first joint of the fingers is hairy, the second joint, answering to the callosity of the gorilla, is generally bare.

As man, then, gradually assumed the erect attitude and the reversed habits of sitting and lying down which it necessarily involves, it seems to me that he must have begun to lose the hair upon his back. But such a partial loss will not fully account for his present very hair-

less condition over the whole body (with trifling exceptions) in the average of all sexes, races, and ages. For this further and complete denudation I think we must agree with Mr. Darwin in invoking the aid of sexual selection, especially when we take into consideration the ornamental and regular character of the hairy adjuncts which man still retains.

In the first place, we have external reasons for believing that sexual selection has produced similar results elsewhere, acting upon a like basis of natural denudation. For among the mandrills and some other monkeys the naked callosities, originally produced, as is here suggested, by physical friction, have been utilized for the display of beautiful pigments; and Mr. Bartlett informed Mr. Darwin that as the animals reach maturity the naked surfaces grow larger in comparison with the size of the body. When we look at the great definiteness and strange coloring of these bare patches we can hardly doubt that they have been subjected to some such selective process.

But if man once began to lose the hair over the whole of his back, shoulders, and haunches, as well as more partially upon his sides, legs, and arms, he would soon present an intermediate half-hairy appearance which is certainly very ludicrous and shabby-looking. Why this middle stage should displease us, it might be rash to guess; yet one may remember that as a rule throughout the mammalia a partially hairless body would be associated with manginess, disease, and deformity. At any rate, it seems to be the fact that, when animals once begin losing their hair, they go on to lose it altogether. One may well believe that among our evolving semi-human ancestors those individuals which had most completely divested themselves of hair would be the most attractive to their mates; and these would also on the average be those which had most fully adopted the erect attitude with its accompanying alterations of habit. Thus natural selection would go hand in hand with sexual selection (as I believe it always does), those anthropoids which most nearly approached the yet unrealized standard of humanity being most likely to select one another as mates, and their offspring being most likely to survive in the struggle for life with their less anthropoid competitors.* It does not seem probable, to me at least, that a naturally hairy species would entirely divest itself of its hair through sexual selection, especially as the first steps of such a process could hardly fail to render it a mongrel-looking and miserable creature; but it seems natural enough that, if the original impulse was given by a physical denudation, the influence of sexual selection would rapidly strengthen and complete the process. Indeed, if a hairy animal once began losing its hair, the only beauty which it could aim at would be that of a smooth and shiny naked black skin.

Woman is the sex most affected in mankind by sexual selection, as

* On the advantages which man or his half-developed ancestor derived from the erect or semi-erect position, see Darwin, "Descent of Man," p. 53.

has been often abundantly shown. Hence we should naturally expect the denudation to proceed further in her case than in that of man. Especially among savage and naked races we should conclude that hairlessness on the body would be esteemed a beauty; and we find as a matter of fact that most such races have absolutely smooth and glistening skins. But in Europe men often develop hair about the chest and legs, though not upon the back and shoulders, while women seldom or never do so. Here we see that the hair reappears in the less differentiated male sex rather than in the more differentiated females, with whom sexual selection has produced greater effects; while it also reappears only on those parts where the original denudating causes do not exert any influence. Similarly, the smooth-bodied negroes, transported to America, and subjected at once to a change of conditions and to circumstances which would render sexual selection impossible as regards the hairlessness of the body, rapidly redevelop hair upon the chest. For we must remember that sexual selection can only act in this direction while a race remains wholly or mainly naked. Clothing, by concealing the greater part of the skin, necessarily confines the selective process to features, complexion, and figure.

As to the poll, beard, whiskers of certain races, we must believe that they are the result of selective preferences acting upon general tendencies derived from earlier ancestors, and perhaps aided in the first-mentioned instance by natural selection. The comparative definiteness of these hairy patches, as of the callosities in the monkeys, stamps them at once as of sexual origin. The poll is probably derived by us from some of our anthropoid ancestors, as crests of hair frequently appear upon the heads of the quadrumana. But as man gradually became more erect and less forestine, as he took to haunting open plains and living more in the sunlight, the existence of such a natural covering, as a protection from excessive heat and light upon the head, would doubtless prove of advantage to him; and it might, therefore, very possibly be preserved by natural selection. Certainly it is noticeable that this thick mat of hair occurs in the part of his body which the erect position most exposes to the sunlight, and is thus adaptively analogous to the ridge of hair which runs along the spine or top of the back in many quadrupeds, and which is not visible in any quadrumanous animal that I have examined. The beard also bears marks of a quadrumanous origin, as Mr. Darwin has shown; but its varying presence or absence in certain races affords us a good clew to the general course of evolution in this particular. For among the bearded races a fine and flowing beard is universally admired; while among the beardless races stray hairs are carefully eradicated, thus displaying the same aversion to the intermediate or half-hairy state which, as I suppose, has been mainly instrumental in completely denuding the body of man. Certainly it is a fact that while we can admire a European with a full and handsome development of hair

upon the chin and lip, and while we can admire an African or a North American Indian with a smooth and glossy cheek, we turn with dislike from thin and scanty hair either in a European, a negro, or an Asiatic. It seems to me that in every case the general æsthetic feeling of the whole human race is the same; but that in one tribe circumstances have made it easier to produce one type of beauty, while in another tribe other conditions have determined the production of another type. Thus, in a negro, a very black and lustrous skin, clear bright eyes, white teeth, and a general conformity to the normal or average negro features are decidedly pleasant even to Europeans when once the ordinary standard has become familiar; * while in a European the same eyes and teeth are admired, but a white skin, a rosy complexion, and moderate conformity to the ideal Aryan type are demanded. Each is alike pretty after its own kind, though naturally the race to which we each ourselves belong possesses in most cases the greatest attractiveness to each of us individually.

Of course, both in the beard of man, and in the general hairiness of his body, as compared with woman, allowance must be made for that universal tendency of the male to produce extended tegumentary modifications, which, as Mr. Wallace has abundantly shown, depends upon the superior vigor of that sex. Yet the period when the beard first shows itself and the loss of color in the hair of both sexes after the reproductive period is past clearly stamp these modifications as sexual in origin.

It must be remembered also, in accounting for the general loss of hair on both back and front of the body, that the older ancestral heredity would tend to make the chest bare, and the newer acquired habits would tend to produce like results upon the back. "In the adult male of the gorilla," says Du Chaillu, "the chest is bare. In the young males which I kept in captivity it was thinly covered with hair. In the female the mammæ have but a slight development and the breast is bare." All this helps us to see how the first steps in the sexually selective process might have taken place, and also why the trunk is on the whole more denuded than the legs. As for the exceptional fact that the arms are hairier on the back than in front, besides the functional explanation already given, we must recollect that the anthropoid apes have long hair on the outer side of the arms, which has probably left this slight memento of its former existence on the human subject. Eschricht has pointed out the curious fact that alike in man and the higher quadrumana this hair has a convergent direction toward the point of the elbow, both from above and from below.

Finally, it may be noted that the hairless condition of man, though

* The mutilations of the face and other parts, which often make savages so ugly in our eyes, though not in their own, are due, as Mr. Herbert Spencer has shown, not to æsthetic intentions, but to originally subordinative practices, as marks of subjection to a conquering king or race.

apparently a disadvantage to him, has probably been indirectly instrumental in helping him to attain his present exalted position in the organic scale. For if, as is here suggested, it originally arose from the reactions of the erect attitude, it must have been associated from the first with the most human-like among our ancestors. Again, if it was completed by sexual selection, it must also have been associated with the most æsthetic individuals among the evolving species. And if, as we have seen reason to believe, these two qualities would tend to accompany one another, then this slight relative disadvantage would be pretty constantly correlated with other and greater advantages, physical and intellectual, which enabled the young species to hold its own against other competing organisms. But, granting this, the disadvantage in question would naturally spur on the half-developed ancestors of man to seek such artificial aids in the way of clothing, shelter, and ornament, as would ultimately lead to many of our existing arts. We may class the hairlessness of man, therefore, with such other apparent disadvantages as the helpless infancy of his young, which, by necessitating greater care and affection, indirectly produces new faculties and stronger bonds of union, and ultimately brings about the existence of the family and the tribe or nation. And if we look back at the peculiarities which distinguish placental from implacental mammals, the mammalia generally from birds, and birds from reptiles, we shall see that in every case exactly similar apparent disadvantages have been mainly instrumental in producing the higher faculties of each successive vertebrate development. Hence it would seem that the hairless condition of man, instead of requiring for its explanation a special intervention of some supernatural agent, is strictly in accordance with a universal principle, which has brought about all the best and highest features of the most advanced animal types through the unaided agency of natural selection.—*Fortnightly Review.*

SKETCH OF PROFESSOR CLIFFORD.

WILLIAM KINGDON CLIFFORD was born at Exeter, May 4, 1845, and at the time of his death, which occurred on the 3d of March, he had therefore not reached the age of thirty-four years. His father was a justice of the peace, and his mother, from whom he inherited a portion of his genius and his constitutional weakness, died early. He first attended the school of Mr. Templeton, of that city, and went to King's College, London, in 1860. In 1863 he entered at Trinity College, Cambridge, in which he secured a foundation scholarship and got the honor of second wrangler in the mathematical Tripos of 1867. Soon after taking his degree he was elected to a fellowship

at Trinity College, filling the post until his appointment to the chair of Applied Mathematics and Mechanics at University College, London, in August, 1871, a position which he held until his death. Professor Clifford was elected a Fellow of the Royal Society in June, 1874. He took prizes and honors wherever he went, which was the more remarkable, as his mind could not tolerate the usual school restraints, and he could not be induced to give much attention to the regular subjects of examination. He had consumption, which greatly impaired his working power in the latter portion of his life; and he died on the island of Madeira, where he had gone with his wife and two children to get the benefit of its milder climate.

Clifford was a genius, and brilliant from his boyhood. He early developed rare mathematical talent, and published the "Analogues of Pascal's Theorem" in the "Quarterly Journal of Mathematics" at the age of eighteen. His mind was at home in all highest mathematical questions, to which he made many profound and original contributions. Professor Sylvester remarked, "All that Professor Clifford adds is the very pith and marrow of the matter." Just before his death he published a little mathematical work, "The Elements of Dynamic," in which his faculty for the subject is fully displayed. It will probably not take high rank as a university text-book, for which it was intended, but is admired by mathematicians for the elegance, freshness, and originality displayed in the treatment of mathematical problems.

Clifford had no special taste for the acquisition of languages, but was interested in their mechanism, and took interest in short-hand, phonography, and telegraphic alphabets. Later in life, however, he mastered modern Greek and Spanish, and dabbled in Arabic and Sanskrit, which, in addition to his earlier Greek and Latin, French and German, landed him pretty heavily in the direction of vocabularies.

He was an early and devoted student of classics, and held extreme High-Church notions when he went to Cambridge. In his knowledge of the "Fathers" he is said to have surpassed the bishops, and his theological acquirements were of great use to him in his polemical and critical discussions. Not satisfied in addressing that very small portion of the public that understands mathematics, versatile in his powers, and of a restless temperament, he was powerfully attracted to those great subjects of scientific and speculative inquiry that have lately become so prominent in the world of thought. Into this field he entered vigorously, and made a strong impression upon the reading public by various able and elaborate articles which appeared in the "Fortnightly" and "Contemporary" Reviews, and in "The Nineteenth Century." He was an extreme and uncompromising rationalist, and although personally greatly liked on account of his gentleness and affability, he made many enemies by the relentless severity of his writing on topics that are conventionally handled with delicacy and caution. He discussed a variety of philosophical subjects, always in a striking and attractive

manner, but can hardly be said to have developed any theories or system of his own.

As an expositor, Professor Clifford was peculiarly and remarkably gifted. Aside from his mathematical attainments, this was the intellectual quality for which he was the most distinguished. His power in this direction is thus described by the "Pall Mall Gazette": "His faculty of explaining the results of scientific investigation in ordinary language, and to persons having little or no special preparation, was such as to amount of itself to genius. The grasp and width of his imagination enabled him to deal freely with the very ideas of the higher mathematics, unfettered by the symbolical expressions and machinery which had first made their conception possible; and he translated the ideas into forms of wonderful simplicity for hearers who little suspected the height and difficulty of the achievement. Long ago, in Cambridge days, he would discuss some complicated theorem of solid geometry, without aid of paper or diagram, in such a way as to make the whole thing seem visibly embodied in space and self-evident. Where the text-books gave a chaos of algebraical manipulation, he would instantly seize the real facts and relations and bring them out into manifest light. Nor did this power fail him even in the most arduous flights of modern geometrical speculation. He was the first in this country to see and enforce the important philosophical bearings of what is called imaginary geometry. His last published paper, which saw the light only a few days before we knew that his work was irrevocably ended, was devoted to explaining with singular felicity and clearness the ultimate foundations of the science of number." The capacity here referred to was so unique and remarkable in Professor Clifford as to win for him a somewhat exaggerated reputation for originality; that is, he would so vividly and ingeniously present a difficult subject as almost to make the views expounded his own.

Among his other accomplishments, Clifford was a skillful gymnast, and as original in his performances as in his intellectual work. He was always executing some striking or eccentric feat, such as hanging head downward, by his toes, and drinking a glass of wine without spilling it; or going up to his room in the college by the water-spout and through the window, instead of the regular staircase. He had more pride in the invention of adventurous and daring gymnastic feats than in his intellectual work. He seems, indeed, to have used his gymnastic exercises as expressions of his genius rather than as means of promoting health. He was of a slender constitution, which was ever on the strain, in one direction or another; and there is reason to think that he was deficient in the important art of taking care of himself, and that, if he had conformed to the first requirement of morality, the duty of doing good to the nature that was in his own charge, he might have done far more good to the world by a prolonged and increasingly useful life.

What shall we say of an education or a culture which not only fails to teach a man how to continue his own life, but which is itself the means of destroying it? On this point Clifford's intimate friend, Pollock, writing about him in "The Fortnightly Review," says: "This was the perilous excess in his own frame of nervous energy over constitutional strength and endurance. He was able to call upon himself, with a facility which in the result was fatal, for the expenditure of power in ways and to an extent which only a very strong constitution could have permanently supported; and here the constitution was feeble. He tried experiments on himself when he ought to have been taking precautions. He thought, I believe, that he was really training his body to versatility and disregard of circumstances, and fancied himself to be making investments when he was in fact living on his capital. At Cambridge he would constantly sit up most of the night working or talking. In London it was not very different, and once or twice he wrote the whole night through; and this without any proportionate reduction of his occupations in more usual hours. The paper on 'The Unseen Universe' was composed in this way, except a page or two at the beginning, at a single sitting which lasted from a quarter to ten in the evening till nine o'clock the following morning. So, too, was the article on Virchow's address. But Clifford's rashness extended much further than this one particular. He could not be induced, or only with the utmost difficulty, to pay even moderate attention to the cautions and observances which are commonly and aptly described as taking care of one's self. Had he been asked if it was wrong to neglect the conditions of health in one's own person, as well as to approve or tolerate their neglect on a larger scale, he would certainly have answered 'Yes.' But to be careful about himself was a thing that never occurred to him."

We append a portion of the estimate of Clifford made in the columns of the "Saturday Review": "The unexpected news of the death of Professor Clifford at Madeira will have brought sadness to an unusally large body of devoted friends, who had hoped that his strength had not waned so far that it might not be recovered under the influence of the mild climate to which he had gone. Nor will it be only by those who had the pleasure of a personal acquaintance with Professor Clifford that the news of his untimely death will be deeply felt. Few men who have passed away at so early an age have been so central a figure as he was in the view of a large portion of the most highly educated among us; and still fewer have achieved this distinction, while at the same time they retained the esteem and admiration of the select few who were competent to estimate their powers and know whether they had been put to a worthy use. But it was always his fate to be conspicuous in whatever circumstances or society he was placed. This was primarily due to his intellectual power, for, without the wonderful rapidity and vigor of thought which he possessed, such

a reputation as his could not have been sustained; but it was in no small degree due also to the peculiar originality of his character, both intellectual and moral, and to the absolutely tireless energy of his versatile mind.

"Those who remember Cambridge some ten or fifteen years ago will readily call to mind his fame while an undergraduate there. From the time when he came up to the university, with the high reputation which he had won while a schoolboy, to the time he left it some eight years afterward to become Professor of Mathematics at University College, London, he was more universally known and discussed among all classes at the university, whether undergraduates, graduates, or dons, than any of his contemporaries. He was indeed at all times a contrast to the normal type. At first, when fresh from school, he appeared as an ardent High Churchman, but he gradually became known as a devoted follower of Mr. Herbert Spencer, and as the champion of those views with which his name has since been identified. But, whatever was the precise phase of thought in which he might be, there was the same brilliant though paradoxical style of asserting and defending his beliefs which made him the terror of authorities and the delight of younger men. He never was in any sense the head of a party there. He was far too eccentric and original to have many followers or imitators. But no one had a wider circle of intimate friends, and no one could be in intimate intercourse with him without being deeply influenced by his views; and it was at that time chiefly by his direct influence on those personally acquainted with him that he produced his effect on the university. But the many-sidedness of his character caused this direct personal influence to be much more widely extended than would have seemed possible to those unacquainted with him. Gifted with an almost equal love for science, mathematics, history, and literature—we may even add gymnastics—he was the center of a knot of devotees of each of these studies, each of whom welcomed him as a comrade and regarded with jealousy his attention to other subjects as being likely to seduce him from the true bent of his genius into less important and congenial studies. And no doubt it was a fortunate thing in this instance that the arrangements for retaining the ablest men at the English universities are so imperfect, that Professor Clifford found no certainty of sufficient scope for his energies there, and resolved to leave that abode of learned leisure, and come to London, to become a mathematical professor, inasmuch as it was this that prevented him from wasting his life in desultory essays in a great variety of directions. No doubt all of these would have shown a power which would have made them remarkable, but they would have been dearly purchased by the sacrifice of the far greater and more abiding results that followed the concentration of his energies on the one or two subjects to which he devoted himself after his departure from the university.

"When resident in London the same qualities that had won him so

many friends at Cambridge still stood him in good stead, and he rapidly drew round him a large circle of warm friends and admirers, among whom might be found almost all the best known names in science or literature. This power of winning the affections of those who were most worthy of friendship was due mainly to the peculiarly winning gentleness and tenderness which characterized him, and made it impossible to resist the charm of personal intercourse with him. Although the nature of his opinions and his style of championing them raised him countless enemies among those who knew him only from his writings and lectures, yet there was no school of thought among the members of which he did not possess some intimate friends. However widely their opinions might differ, it seemed to be quite impossible for any one to feel hostility toward him after becoming personally acquainted with him. The versatility of his mind aided this greatly, for it gave to his conversation a charm which was quite peculiar, and which was felt alike by the most different classes of minds. There was no subject from which he used not to draw apt illustrations or expressive metaphors, which came clothed in language as quaint and as original as it was appropriate. Whatever he discussed seemed to become full of suggestiveness. These qualities gave great additional value to his mathematical lectures.

"With his style of teaching, the most valuable part of the instruction was the indirect effect of the lessons; the actual matter in hand was distinctly subordinate to the general training in the fundamental ideas and principles of the subject which its discussion enabled him to give. Everything was treated from the point of view in which it least needed the aid of artificial methods and conventions, so that its direct connection with the broad underlying principles common to a whole class of subjects might be immediately perceived. This dislike to artificial methods was almost a passion with him. He had great faith in the superiority of this style of teaching, and always maintained that it was the easiest as well as the best, a proposition to which the experience of most teachers would not lead them to assent. Perhaps it was his own special power of clear exposition which enabled him to succeed so well in thus handling his subjects in their most general form, instead of starting from simple and particular cases, and only taking up more general theorems after the simpler ones had been mastered by his pupils; but, whether or not this was the case, it is certain that he had all the success in his teaching that he could desire.

"It is a signal proof of the beauty of Professor Clifford's personal character that, in forming an estimate of him, one should so naturally and inevitably think first of his general qualities, and only in the second place of his claims to fame as a mathematician. For it was in the latter character that he first gained his great reputation, and it is in that that his claims to genius are the strongest. No one of his contemporaries ever approached Professor Clifford in his marvelous

power over the intricate and abstruse branches of mathematics to which he gave his main affections, and to find his equal we should have to look among veterans whose names will for ever be identified with these subjects. Such was his prodigious grasp over the phantoms that people these remoter regions of thought, that while little more than a boy he seemed fit to take his place among the masters of these studies. And there can be no doubt that, if the innate restlessness of his nature would have permitted him to accept the quiet of a mathematician's life, he might have left behind him what would have entitled him to take rank as one of our greatest mathematicians. But it is hard to forego the pleasure of using powers which one is conscious of possessing, and the temptation to which the versatility of his mind subjected him was wellnigh fatal to his reputation as a specialist. Every now and then something would turn his energy into these lines, and he would show by some fragment what magnificent work he was capable of doing; but it was for a long time doubtful whether he would ever do justice to himself in this respect, and by more continuous application to some special subject produce results worthy of his powers. As time went on, however, this changed; during the last few years there were fewer signs of the old desultoriness, and both in his 'Elements of Dynamic' and his various mathematical papers there were abundant traces of the concentration of effort which alone was needed to secure success. But, alas! this was only too speedily succeeded by the leisure of the sick-bed. Perhaps it was the feeling of decaying strength which first made Professor Clifford limit the sphere of his efforts, and seek to finish some of his many projects, instead of forming new ones. Whether this was so or not, it was not the less a gain to the world, though even now what we possess should be considered only as indications of what his powers would have been when fully developed. Few, if any, have done such brilliant work and yet died leaving us to feel that it must be taken only as the promise, and not as the measure, of their powers.

"But what the mathematical world lost in this want of specialization of Professor Clifford's powers was gained by the general educated public. His powers as a scientific expositor were as remarkable as his mathematical abilities. His talent did not lie in experimental illustration; on the contrary, he seldom, if ever, resorted to it. Nor did he ever condescend to the nurse-like prattle by which some scientific lecturers make themselves comprehensible to the meanest intellects—but to those only. There was not a sentence, or a scientific statement, in one of Professor Clifford's lectures of which he need have been ashamed in an address to the most scientific or learned society."

CORRESPONDENCE.

A CORRECTION.

To the Editors of the Popular Science Monthly.

IN your February number, the article on "The Old Phrenology and the New," by Dr. Andrew Wilson, struck me as having been conceived not only with some degree of prejudice, but a lack of sufficient care in reference to facts. I will refer you to one case which relates to Mr. Gage, who had an iron bar driven through his brain by a blasting accident. Dr. Wilson conveys the idea that his mental faculties were unaffected by this most extraordinary injury and loss of brain. Dr. J. M. Harlow, now of Woburn, Massachusetts, had charge of the case, and followed with great care the wanderings of this young man, after he recovered from his injury; and after his death, which occurred in California, twelve years after the accident, he was able to get the cranium and the iron bar that passed through it, and presented them, with a detailed account of the case, to the Massachusetts Medical Society; and they are now in the Museum of Harvard College. In this paper Dr. Harlow says, in reference to the changed condition of the mental faculties: "His physical health is good, and I am inclined to say he has recovered. Has no pain in head, but says it has a queer feeling which he is not able to describe. Applied for his situation as foreman, but is undecided whether to work or travel. His contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again. The equilibrium or balance, so to speak, between his intellectual faculties and animal propensities seems to have been destroyed. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operations, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, though untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart business man, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decided that his friends and acquaintances said he was 'no longer Gage.'"

In this case of injury of the brain and recovery, unparalleled, and of world-wide interest, I deem it proper that the error in reference to the condition of the intellectual faculties should be corrected through your periodical. Truly,

JOHN CLOUGH.

WOBURN, MASSACHUSETTS, *March* 31, 1879.

EDITOR'S TABLE.

THE LONDON TIMES ON INTERNATIONAL COPYRIGHT.

THE circular of Messrs. Harper, announcing that they will favor an international copyright measure, is justly regarded by the English press as significant in relation to the progress of the question, and they have made it the occasion of general comment. The tone of criticism is dissonant and, on the whole, encouraging, though, as has become the habit, predominantly abusive and carping. But it must be confessed that Harpers' circular was somewhat calculated to provoke hostile English criticism. The conditions under which they are willing to concede to foreign authors the legal right of property in their works, which are not only that the books shall be manufactured in this country, but by American citizens, and published within three months after their issue at home, are denounced as so illiberal as to be hardly worth entertaining. The London "Times," in a first article upon the subject, was disposed to "welcome the result" on the ground that something is gained

when "the principle of piracy has been abandoned, and the black flag of literature hauled down." But in a second article the view taken is less favorable. It sees numerous difficulties, and thinks "there is very little use in discussing these farcical proposals which the publishers of the transatlantic cities have elaborated." It thinks the proposition to throw open the power of publishing books to everybody, subject to the obligation of paying a royalty to the author to be fixed by law, is "not yet sufficiently discussed." And so, on the whole, it concludes that we had better postpone the subject, and wait for something more satisfactory.

The "Times," however, is disingenuous in characterizing the plan suggested by Messrs. Harper as elaborated by the publishers of transatlantic cities. That house speaks only for itself, and does not undertake to represent other American publishers. Both the proviso that the publisher shall be an American citizen, and the time-limit assigned for reprinting, will be held by others as not essential to the American position, and as open to modification in settling the details of an international arrangement.

We speak of the "American position," and are fairly justified in doing so, for there is now wide and decisive agreement that foreign books copyrighted in this country, must be manufactured in this country. In granting the copyright to English authors, and placing them upon the same footing as our own, we yield all the rights of the case that can be demanded in the name of justice. Every nation that grants copyrights even to its own authors, qualifies and limits them by considerations of public expediency, it being assumed that the community has duties to itself as well as to authors. This country would therefore be vindicated by universal precedents in giving the new arrangements such a form that they will not be injurious to important American interests. The requirement that foreign books copyrighted in this country shall be printed in this country is dictated by the first law of nature—the principle of self-preservation. Any international copyright that did not enforce this condition would be destructive to an extensive and valuable domestic industry, and would put the American book-market at once and completely under the control of foreign publishers, thousands of miles away from us. Under a state of things which, although it may not have been just, has nevertheless been legal, the publishing interest in the United States has grown into extensive proportions. We have numerous manufacturing establishments of all kinds for every branch of the business. We have heavy investments in paper manufactories, printing-houses, binderies, and shops for making all the necessary machinery, and we have multitudes of trained mechanics to carry on the required operations.

Whether all this capital shall be sunk, and all this industry paralyzed, and a reading people shall cease to supply itself with books in accordance with its own tastes and preferences, depends upon the *form* of copyright adopted, if that measure is to be carried out. And when it is remembered that the foreign publisher has no claims upon us whatever, and that we discharge all our obligations in protecting the property rights of the foreign author, it is obvious that every consideration of national expediency dictates that we should take care of our own interests in this matter.

It is usual to represent the policy here maintained as inspired by the greed of mercenary and monopolizing American publishers. It is no such thing. It is life or death to the whole business. To yield the point is to transfer the American book-trade almost bodily to England. In requiring copyrighted books to be printed here, the American publisher only stipulates for

an equal chance with the English publisher, which he could not have if this measure is put upon any other basis. We say let the English publisher come over and compete with us if he wishes to. All we ask is equal terms, and that he shall not be given that fatal advantage of us which he would get by an unrestricted copyright.

But it may be said that this is an illiberal policy; and that, when all the tendencies of international intercourse are in the direction of freedom and expansion, such a scheme as this is narrow and obstructive. The "Times" virtually charges this, in saying "the gross delusions of protection may extend to cover the book-selling business as well as the making of cotton cloths and the forging of iron." And yet the burden of English complaint for the last fifty years has been that our trade in English books is quite too free, and our policy liberal and lax to a most scandalous extent. What they have demanded is, that we contravene this freedom of commerce by restrictive legislation. Copyright is the antagonist of free trade. Were perfect liberty of commerce proclaimed to-morrow between nations (as it now exists between the States of this nation), international copyright would make books an exception by protecting them from all competing production and open traffic. The author by his copyright invests his publisher with a monopoly, by which he controls and restricts the trade in his book to any extent that pleases him. With an unqualified international copyright, and the fullest freedom of trade otherwise, the London publishers would rule the market in this country for all the works of English authors. American publishers would be excluded from competition with them. We hold that the principle of copyright is wise, as it is the only practical way yet devised by which an author can have secured to him the available right of property in his book, and we demand that English authors shall have the full benefit of it, but on no principle of liberal trade arrangements can we be asked to subject our book markets to the exclusive control of English manufacturers.

The "Times" says that the great American houses have been driven into this position of favoring an international copyright, by the interference of "some Chicago men" who are cutting into and underselling the established firms of New York and Philadelphia. That cut-throat proceeding, as it is a natural consequence of the existing system, is certainly a valid reason for condemning the system and putting an end to it. But the "Times" misrepresents the facts in saying that this is the origin of the plan of international copyright now under consideration. Its own columns might have been consulted for a confutation of the statement. The project of international copyright, in behalf of English authors, was urged long before the Chicago raids referred to were undertaken, and it was explicitly presented to the English people by an American publisher writing in the "Times" as early as 1871.

The writer objects that, by the plan proposed, "the English author is not to be allowed the rights of an ordinary possessor of property." But does it expect that the Americans will go further than the English themselves, in protecting the rights of their authors? Is it not now, and has it not long been, the policy of the English Government to deny to its authors "the rights of an ordinary possessor of property" in his literary creations, and does it not protect them as mere favors and transient privileges which are left to expire after a few years? Again, the writer in the "Times" accuses us of robbing the author of *half* his rights. He may, if so minded, take the remainder, as "half the recognition of a right must have some value." To be paid the full price for his work, according to contracts that he may make with any publisher among

forty millions of people, thus appears to be only half what we owe to the English author. The implication is, that his right to force his foreign publisher upon us is just as clear and strong as his right of property in the book he has produced. This absurd proposition is of course assumed—not argued.

CURIOUS SURVIVALS OF SAVAGISM.

Singularly enough, the time when men know least of this world is the time when they profess to know most of the other. The primitive man is first of all a believer in ghosts. While so ignorant that he can not count ten, he yet has a theory of a future life. Strip the civilized man of his acquirements and get down to the primal core of savagery, and you find him a spiritualist. At a time when all interpretations of nature were illusive, and in fact engendered by these illusions, there arose the notion of a ghost realm, occupied by phantoms of the departed dead, who can still communicate with living men and interfere in human affairs. And, as these causes are common to the lowest tribes, so the superstitions are universal in the savage state.

And they were not mere idle speculations. The other world was held to be of far greater moment to man than this world, because of the power of its spirits over the fate of mankind. But, although potent and dangerous, the ghosts of the dead were supposed to be still accessible to human influence. It was believed that they could be propitiated by supplications, offerings, and sacrifices, which took endless forms as religious rites among the lower races. So completely, indeed, were men enslaved to their spiritualistic fancies that life itself had not the slightest value when there was supposed to be some other-world inducement for destroying it. Men were immolated without hesitation to please or appease the ghosts of another sphere. This world was ruled with the most savage ferocity in the supposed interests of the next. The amount of human sacrifice—of deliberate butchery of human beings—that has been occasioned by gross spiritual delusions relating to another life is appalling to think upon. Starting with the idea of an imaginary sphere, filled with grim shadows to be placated or honored, men, women, and children have been slaughtered by countless thousands at religious altars, at funerals, and at tombs. Their souls were sent to accompany dead chiefs, wives were burned on funeral piles to accompany their husbands, some were sent to carry messages to the spirits, some to propitiate ill-natured demons, and the whole proceeding serves to demonstrate the terrible intensity of the primitive belief that the other world is everything and this world nothing.

These practices, originating in primeval spiritualism, in the infantine stages of society, are by no means confined to those stages; they continue on as society advances. Among the Mexicans, for example, after they had become considerably civilized, such was the bloody fervor of their spiritualism that human sacrifices, on a great scale, were part of their system of religious rites. We are told that "every great man's chaplain was slain to perform for him religious ceremonies in the next life as in this"; again, "The number of victims was proportioned to the grandeur of the funeral, and amounted sometimes, as historians affirm, to two hundred." Also, in Peru, "when an Inca died, his attendants and favorite concubines, amounting sometimes, it is said, to a thousand, were immolated on his tomb."

These ideas and practices having the most terrible sincerity and severity where the darkness of human ignorance is thickest, being most widespread and deeply rooted in the lowest barbarism,

we should expect that with the growth of intelligence they would disappear. But this process is very slow. The superstitions became the nucleus of organized religions, and are contained in a thousand theologies. Yet these beliefs at length lose their grosser forms; many of them are dissipated, others modified. They influence men's conduct less and less, and are finally held as mere empty traditional beliefs. Just in proportion to the increase of men's knowledge of nature, superstition has relaxed its stringency. As science grows, and the exploration and cultivation of this world become more absorbing, there is necessarily less attention given to the other world. This is deplored by many as a decline of faith. They raise loud lamentations over the decay of religion, the apathy of churches, the spread of materialism, and the extension and deepening of scientific influence. As a consequence, we now and then find men brooding over this state of things until the restraints of reason and common sense give way, and they announce themselves as divinely called upon to perform some great work that shall startle a faithless age, and kindle anew the old fervor of spiritualistic belief. Two such relapses into rank primeval superstition have recently occurred.

Charles F. Freeman, of Cape Cod, the other day piously sacrificed the life of his little daughter, in obedience to what he supposed to be a spiritual mandate from the other world. He was a Second Adventist, and full of intense belief in the miraculous coming of Christ to rescue the world from unbelief. Whether he attended the great Second Advent Convention that was held in New York last year we do not know, but he evidently laid to heart its inculcation of the duty of literally interpreting the Scriptures. He is reported as an assiduous Bible student, who quotes Scripture with great fluency, and is ready with an apposite text for every doctrine that he maintains. The old Hebrews indulged in the same sanguinary practices as other barbaric tribes. In their books there are records of one father sacrificing his daughter, and of another father preparing to immolate his only son. Freeman had, no doubt, often heard these transactions discussed in the pulpit, and Abraham applauded for the strength of his faith. If such a test was ever necessary, he thought it a thousand times more necessary in this faithless age than ever before; so he killed his child, at what he claims to be the peremptory requirement of the Deity he worshiped, that a miracle might be performed, and his faith displayed before an unbelieving generation. The whole ghastly affair is simply an instance of survival of one of the spiritual usages of savagery, when bloodthirsty devils were regular objects of worship.

Another case of falling back into the mental condition of barbarism has been recently afforded by the Superintendent of Schools of the City of New York, Mr. Henry Kiddle. Yielding to that morbid craving after the marvelous, which is a distinctive mark of undeveloped or retrograded natures, he had been exploiting mediums, and comes forward with what he calls a revelation from the spiritual sphere. Two members of his family have been for some time talking to him the most demented drivel, which he accepts as spiritual communications, or messages from the ghostly inhabitants of another world; all of which he has minutely written down and published in a book. Kiddle, like Freeman, as the newspapers avouch, is "very conscientious," "thoroughly sincere," "profoundly in earnest," etc., and there is no doubt of the genuineness of his credulity. We have looked over his book, and found it to consist of the merest rubbish. Mr. Kiddle says of these communications, in his preface, that he "*knows* they are not the offspring of imposture or delusion. *They come from the world of spirits.*

This is solemnly attested as a fact undeniable and irrefutable." Now, when Mr. Kiddle declares that he *knows* there is no delusion in the matter, he simply means that he solemnly believes it, which is the basis on which the mysteries of another world have been revealed from the earliest origin of these superstitions. He gives exactly the kind of evidence that would require us to believe all the insane hallucinations of our lunatic asylums, for no man is so undeniably and irrefutably sure that he is not deluded as a madman.

Freeman had a mission, and regarded himself divinely chosen for a great work. So does Kiddle. He is commissioned to open new relations with the unseen world. He announces "a new spiritual revelation," a "a new dispensation of religious light," showing "the existence of a future world." Under an "obligation imposed upon the editor by Divine Providence," he promulgates "a revelation of the future destiny of mankind, of transcendent importance to them both here and hereafter." And so all the *old* spiritual revelations are failures; the existence of a future world remained still to be proved; and the human race having struggled in vain for thousands of years to arrive at this truth of transcendent moment, Mr. Kiddle arrives at it by the aid of a couple of green mediums in the space of about nine months! Fortunate Mr. Kiddle!

Curiously enough, the Superintendent of Schools of the City of New York, who has given his life to the interests of knowledge, now gives notice that he has not a very high opinion of the later tendencies of science, and in this he is not alone. But he further intimates that his revelations of a supersensuous world may be designed by Heaven to thwart the influence of this bad science. We quote a passage from his introductory chapter, and beg the reader to notice that what follows is not from a spirit, but from Kiddle himself:

"When distinguished scientists sneeringly ask: '*Who has ever seen the soul* with the very best microscope that can be made? What physiologist *has ever found any human spirit* in his most minute dissections?'—when the proud scientist, filled with vainglory by the discovery of some of the laws of light and heat, or puffed up with vanity because he has caught a vision of something which he daringly calls the 'physical basis of life,' and, ready to fall down in adoration before his new-found deity, *Protoplasm*, announces that he finds in matter the 'promise and potency of every form of life;' or when he cries 'Amen' to his brother scientist who has traced, by the law of *evolution* and the 'survival of the fittest,' to a common origin himself and all the rest of the animal creation, and glories in his quadrumanous ancestry—when such is the age in which we live—an age characterized by the worst forms of irreligion—is it improbable that the All-Merciful Father should come again to the rescue of his benighted creatures, and for this purpose should in part unveil the glories of the supersensuous world to which all are tending?"

Mr. Kiddle's book, as this extract alone illustrates, is a very debilitated piece of intellectual work. Our first impression was that the man had undertaken to perpetrate a huge joke, but we became soon convinced that he is not himself. Various indications suggest an unhealthy state of mind, that is probably caused by some exhaustion or failure of the brain. The suddenness of his change of conduct at the age of fifty-five in regard to spiritualism; the slyness with which all was done, even to the printing of his book; his obstinacy in refusing to listen to reason and remonstrance in matters where others are concerned; and his egotistic hallucination in supposing himself divinely called upon to do a great religious work—these, taken in connection with the imbecile and idiotic

character of his book, show mental unsoundness, and suggest that the mind's organ is not in a proper condition. One thing is certain: the maker of such a book is not a fit man to be in charge of educational interests. If he is beside himself, that ends it; if not, the case is still worse: the Board of Education should have granted him leave of absence, and sent him away to recruit.

LITERARY NOTICES.

The International Scientific Series, No. XXVI.—Modern Chromatics, with Applications to Art and Industry. By Ogden N. Rood, Professor of Physics in Columbia College. With 130 Original Illustrations. D. Appleton & Co. Pp. 329. Price, $1.75.

In his contribution to the "International Scientific Series" of a volume on modern chromatics, Professor Rood has filled a gap in the scientific literature not only of this, but also of European countries. There was wanted a well-executed popular treatise on the science of color for general readers, in which they will find a familiar and satisfactory explanation of chromatic phenomena as they are now interpreted, and as illustrated in the aspects of nature and in the applications of art.

Professor Rood was asked to prepare such a volume for this series because he possesses in an eminent degree the qualifications necessary to do justice to the subject. In the first place, he was specially prepared to undertake it by his education and training as an experimental physicist. At home in this general field of research, with an aptitude for subtile and refined investigations, he has always been particularly interested in this line of inquiry, and has attained a European reputation as an authority upon the subject. From this point of view, probably, no man was so well equipped to make an instructive volume on chromatics that should be fully up to the times as Professor Rood.

But he possesses another qualification which is no less important for the work. He is himself an artist, with both enthusiasm and a true genius for the profession, and who has devoted much time to drawing and painting. His sketches are prized by many who are so fortunate as to possess them, and it is well understood that, if he had chosen to devote himself to it, he would have attained preëminent distinction as an artist. This combination of scientific knowledge with practical experience in the art of managing colors could not fail to be of great advantage. Numerous questions and problems relating to chromatics which are interesting and important to artists came before him, and were elucidated with such skill and useful results that he was called upon to give lectures, explaining his views, before the art classes at the New York Academy of Design.

When solicited to prepare the present volume, Professor Rood replied that he was not a book-maker, and had no inclination merely to compile or to write a volume upon the science of color. He said that to make such a book valuable in the present state of the subject would involve a very considerable amount of scientific investigation in clearing up numerous points to get the work in anything like satisfactory shape. For these researches time would be necessary, which would inevitably delay the publication. The volume was prepared under these conditions, so that, in a very important sense, it is a new work. Every chapter of it bears witness to the patient and painstaking solicitude of the author to make his statements clear, valid, and complete. A consultation of his index will show to how large a degree the volume is original. Only results and explanation are given in the text, and those who care to go over the experimental demonstrations by which they have been reached will consult the scientific periodicals in which the descriptive papers are to appear.

Professor Rood, as we have intimated, declines to classify himself as a book-maker, and does not seem to have ever been troubled in the slightest degree with the ambition of authorship. He has written many technical papers for scientific journals, which may be thought rather a poor apprenticeship for getting up a popular book. But he has attained a degree of excellence in the literary art of his book which is not a

little surprising; it has the rare merit of being written in a style suited to its object. It is clear, simple, direct, and puts the matter before the reader in a straightforward, common-sense way, so as thoroughly to interest him in the subject.

The work is full of fresh illustrations, drawn by the author, and exhibiting new points and relations of the subject, and a chromatic plate is prefixed to the volume, which has something the character of a key, and will be specially useful to those who may desire to color the diagrams in the book. One of the most interesting features of the volume is the large number of instructive and attractive experiments in colors which it describes or indicates.

The work is strictly systematic, and treats the subject of chromatics comprehensively, as will be seen by glancing at the titles of the chapters.* We can give no idea of the real scope of the work by any analysis of its contents, or even a conspectus of the new ideas and suggestions contributed by the author; but some of his observations in Chapter XVIII., on "Color in Painting and Decoration," are so suggestive in relation to a subject occupying a good deal of public attention at present, that we quote them:

The aims of painting and decorative art are quite divergent, and as a logical consequence it results that the use made by them of color is essentially different. The object of painting is the production, by the use of color, of more or less perfect representations of natural objects. These attempts are always made in a serious spirit; that is, they are always accompanied by some earnest effort at realization. If the work is done directly from nature, and is at the same time elaborate, it will consist of an attempt to represent, not all the facts presented by the scene, but only certain classes of facts, namely, such as are considered by the artist most important or most pictorial, or to harmonize best with each other. If it is a mere sketch, it will include not nearly so many facts; and finally, if it is merely a rough color-note, it will contain perhaps only a few suggestions belonging to a single class. But in all this apparently careless and rough work the painter really deals with form, light and shade, and color, in a serious spirit, the conventionalisms that are introduced being necessitated by lack of time or by choice of certain classes of facts to the exclusion of others. The same is true of imaginative painting: the form, light and shade, and color are such as might exist or might be imagined to exist; our fundamental notions about these matters are not flatly contradicted. From this it follows that the painter is to a considerable extent restricted in the choice of his tints; he must mainly use the pale unsaturated colors of nature, and must often employ color-combinations that would be rejected by the decorator. Unlike the latter, he makes enormous use of gradation in light and shade and in color; labors to express distance, and strives to carry the eye beneath the surface of his pigments; is delighted to hide as it were his very color, and to leave the observer in doubt as to its nature.

In decorative art, on the other hand, the main object is to beautify a surface by the use of color rather than to give a representation of the facts of nature. Rich and intense colors are often selected, and their effect is heightened by the free use of gold and silver or white and black; combinations are chosen for their beauty and effectiveness, and no serious effort is made to lead the eye under the surface. Accurate representations of natural objects are avoided; conventional substitutes are used; they serve to give variety and furnish an excuse for the introduction of color, which should be beautiful in itself apart from any reference to the object represented. Accurate, realistic representations of natural objects mark the decline and decay of decorative art. A painting is a representation of something which is not present; an ornamented surface is essentially not a representation of a beautiful absent object, but is the beautiful object itself; and we dislike to see it forsaking its childlike independence and attempting at the same time both to be and to represent something beautiful. Again, ornamental color is used for the production of a result which is delightful, while in painting the aim of the artist may be to represent sorrow, or even a tragic effect. From all this it follows that the ornamenter enjoys an amount of freedom in the original construction of his chromatic composition which is denied to the painter, who is compelled by profession to treat nature with at least a fair degree of seeming respect. The general structure of the color-composition, however, being once determined, the fancy and poetic feeling even of the decorator are compelled to play within limits more narrow than would

* Chapter I., Transmission and Reflection of Light; II., Production of Color by Dispersion; III., Constants of Color; IV., Production of Color by Interference and Polarization; V., Colors of Opalescent Media; VI., Production of Color by Fluorescence and Phosphorescence; VII., Production of Color by Absorption; VIII., Abnormal Perception of Color and Color-Blindness; IX., Young's Theory of Color; X., Mixture of Colors; XI., Complementary Colors; XII., Effects produced on Color by a Change of Luminosity, and by mixing it with White Light; XIII., Duration of the Impression on the Retina; XIV., Modes of arranging Colors in Systems; XV., Contrast; XVI., The Small Interval and Gradation; XVII., Combinations of Colors in Pairs and Triads; XVIII., Painting and Decoration.—Note on Two Recent Theories of Color.—Index.

be supposed by the casual observer. It is not artistic or scientific rules that hedge up the path, but his own taste and feeling for color, and the desire to obtain the best result possible under the given conditions. In point of fact, color can only be used successfully by those who love it for its own sake apart from form, and who have a distinctly developed color-talent or -faculty; training, or the observance of rules, will not supply or conceal the absence of this capacity in any individual case, however much they may do for the gradual color-education of the race.

From the foregoing it is evident that the positions occupied by color in decoration and in painting are essentially different, color being used in the latter primarily as the means of accomplishing an end, while in decoration it constitutes to a much greater degree the end itself. The links which connect decoration with painting are very numerous, and the mode of employing color varies considerably according as we deal with pure decoration, or with one of the stages where it begins to merge into painting.

The simplest form of color-decoration is found in those cases where surfaces are enlivened with a uniform layer of color for the purpose of rendering their appearance more attractive: thus woven stuffs are dyed with uniform hues, more or less bright; buildings are painted with various sober tints; articles of furniture and their coverings are treated in a similar manner.

The use of several colors upon the same surface gives rise to a more complicated species of ornamentation. In its very simplest form we have merely bands of color, or geometrical patterns made of squares, triangles, or hexagons. Here the artist has the maximum amount of freedom in the choice of color, the surfaces over which it is spread being of the same form and size, and hence of the same degree of importance. In such cases the chromatic composition depends entirely on the taste and fancy of the decorator, who is much less restricted in his selection than with surfaces which from the start are unequal in size, and hence vary in importance. After these simplest of all patterns follow those that are more complicated, such as arabesques, fanciful arrangements of straight and curved lines, or mere suggestions taken from leaves, flowers, feathers, and other objects. Even in these, the choice of the colors is not necessarily influenced by the actual colors of the objects represented, but is regulated by artistic motives, so that the true colors of objects are often replaced even by silver or gold. Advancing a step, we have natural objects, leaves, flowers, figures of men or animals, used as ornaments, but treated in a conventional manner, some attention, however, being paid to their natural or local colors, as well as to their actual forms. In such compositions the use of gold or silver as backgrounds or as tracery, also the constant employment of contours more or less decided, the absence of shadows, and the frank disregard of local color where it does not suit the artist, all emphasize the fact that nothing beyond decoration is intended. Up to this point the artist is still guided in his choice of hues by the wish of making a chromatic composition that shall be beautiful in its soft, subdued tints, or brilliant and gorgeous with its rich display of colors; hence intense and saturated hues are often arranged in such a way as to appear by contrast still more brilliant; gold and silver, black and white, add to the effect; but no attempt is made to imitate nature in a realistic sense. When, however, we go some steps further, and undertake to reproduce natural objects in a serious spirit, the whole matter is entirely changed; when we see groups of flowers accurately drawn in their natural colors, correct representations of animals or of the human form, complete landscapes or views of cities, we can be certain that we have left the region of true ornamentation and entered another which is quite different. A great part of our modern European decoration is really painting—misapplied.

"American Chemical Journal." Edited, with the Aid of Chemists at Home and Abroad, by Ira Remsen, Professor of Chemistry in the Johns Hopkins University. Vol. I., No. 1. Fifty cents per number. Baltimore: Innes & Co.

As we gather from the announcement, the first object of this new Journal will be to collect the good original papers written by American chemists. It will aim to be a medium of communication between the chemists of this country by recording their researches. But at the same time it will reprint articles and abstracts of articles from other chemical periodicals, and will also print reports of progress in recent investigations and reviews of chemical publications. The first number opens with an article contributed by Dr. Wolcott Gibbs, on the complex inorganic acids, and closes with a report on applied chemistry, by Professor J. W. Mallet. The numbers of the Journal will contain from sixty-four to eighty pages. Six will form a volume of from four to five hundred pages, which will probably appear within a year. Subscription, three dollars per volume in advance. All success to the new enterprise!

Journal of the American Chemical Society, Vol. I., Nos. 1–3. Committee on Papers and Publications: H. Endemann, Ph. D., Editor; Arno Behr, Ph. D.; Gideon H. Moore, Ph. D. New York: Lehmaier & Brother, 162 William Street.

"The American Chemical Society," though young, is vigorous, and is going on from strength to strength. It has already

a strong membership, and is doing a good deal of valuable work. The Society has permanent rooms at No. 11 East Fourteenth Street, which are open every evening from eight to ten o'clock. The "Journal of the American Chemical Society," like the "American Chemical Journal," is designed not for the outside world, but for those initiated into the mysterious technicalities of the science.

Treatise relative to the Testing of Water-Wheels and Machinery. With Various other Matters pertaining to Hydraulics. By James Emerson. Second edition. Springfield, Mass.: Weaver, Shipman & Co. Pp. 216.

This book has an interest for manufacturers using water-power. It seems that not long ago the testing of water wheels, with a view to determining their efficiency, was so difficult and expensive an operation, that the proprietors of new patent wheels of all kinds were tempted to make gross exaggerations of their effectiveness, because there were no ready means of getting at the actual facts. The author of this work accordingly addressed himself to the task of finding out some cheaper and more available means of making trustworthy measurements. This volume is chiefly devoted to that technical subject, and abounds in pictures of water wheels, and formidable tables. It also gives much information regarding other forms of mechanism.

An Outline of General Geology. With Copious References designed for the Use of both General and Special Students. By Theodore B. Comstock, B. Ag., B. S., of the Cornell University. Ithaca: University Press. Pp. 82.

This is a *vade mecum* for the use of geological students that has grown out of the author's syllabus of elementary lectures, to a mixed class of students, on economic geology and paleontology. It does not profess to be a text-book, but a help to study in connection with such works as Dana's "Manual of Geology" and Le Conte's "Elements of Geology." It gives summaries of important information and many useful references, blank leaves being freely inserted for convenience in making notes. Such a volume can not fail to facilitate the student's work in various ways.

Sewer-Gases, their Nature and Origin, and how to protect our Dwellings. By Adolfo de Varona, A. M., LL. B., M. D., etc. Brooklyn: "Eagle" Book Printing Department. 1879. Pp. 156. Price, 75 cents.

This little book contains much valuable information that every householder in our cities and towns should be familiar with. Many of the worst diseases are now believed to owe their origin to sewer or kindred emanations which find their way into houses, through defective planning and workmanship, both of which could be avoided if those most interested would take the trouble to inform themselves on the subject. In the present work the composition of sewer-gas, as determined by various competent analysts, is first considered; the relation of these gases to disease is next treated; then comes a description of the conditions under which sewer-gases are generated, the size, form, and construction of sewers, and the manner in which the sewer is connected with the house: this completes the first part of the book. The second part is devoted to the subject of the protection of dwellings against the entrance of sewer-poison. The author confines himself to facts and their common-sense applications; and, although the information which he gives may probably be obtained elsewhere, it is here brought together in a brief and convenient form, and unencumbered with the trash that characterizes so many works on hygienic subjects. The style of binding and display on the cover are hardly in keeping with the contents of the book, but this maybe remedied in a future edition.

Reading as a Fine Art. By Ernest Legouvé, of the Académie Française. Translated from the Ninth Edition by Abby Langdon Alger. Boston: Roberts Brothers. Pp. 97. Price, 50 cents.

A very suggestive and useful little monograph on the subject of reading aloud. The writer believes in an art of reading, which is capable of being generally acquired, and he certainly makes out a very good case. He gives the rules for reading, and deals with the philosophy of declamation in a very lively and pleasant manner, which has been well rendered in an excellent translation.

Ocean Wonders: A Companion for the Seaside. Freely illustrated from Living Objects. By William E. Damon. New York: D. Appleton & Co. Pp. 229. Price, $1.50.

This is an elegant little volume, profusely and beautifully illustrated, and abounding in descriptions of those curious creatures of the sea, most of which can be actually observed by the dwellers upon the shore. It is hence very properly designated as a companion for the seaside. But that which is unique in the volume, and gives it its peculiar value, is the author's first-hand familiarity with his subject, and the large amount of trustworthy, practical information it contains, that will be of use to those who wish to make collections for themselves. In this respect the author's testimony is emphatic and decisive. He says: "It is not so easy as it appears at the first glance to assure success in establishing a private aquarium. Whatever value this volume possesses is due to the fact that I give no second-hand directions, but the results and deductions of my own dearly bought personal experience, attained at a considerable outlay, not only of time and trouble, but also of money, in obtaining many rare and scarce specimens of marine life, and in experiments to ascertain the kind of animals which would survive captivity. In the latter, I hope my directions or hints will materially diminish the amount of expenditure for such amateurs as may peruse this book."

The volume is admirably written, but of this our readers may judge for themselves, as some of Mr. Damon's contributions to natural history have already appeared in "The Popular Science Monthly."

The Life and Letters of Frances Baroness Bunsen. By Augustus J. C. Hare. Two volumes in one. New York: Routledge & Sons. Pp. 1,002. Price, $5.

Frances Waddington was the daughter of an English baronet, who lived in Wales. When she was at the age of eighteen, the family visited Rome, and she there met, captivated, and married young Charles Bunsen, a German, and afterward distinguished as a diplomatist and historian. They lived some twenty years in Rome, during which Bunsen represented the Prussian Government in an official capacity; and he was then sent to London to represent Prussia at the Court of St. James. He retained this position, residing in London, about a dozen years, when the family returned to Germany. The Baroness was a woman of remarkable character, who had a long career in the most favored circles of English and Continental society. She left the record of her observations and experience in a great number of letters, which her biographer, Mr. Hare, has made free use of in editing the work. She had a large family, to which she was greatly devoted, and the history of her life is an eminently wholesome and instructive piece of biographical work.

The American Plant-Book, for the Convenient Preservation and Analysis of Pressed Flowers, Ferns, Leaves, and Grasses. By Harlan H. Ballard and Proctor Thayer. Slote & Co., 1879.

This book, which is neatly bound, provides for the fastening of about one hundred flowers upon its pages. Opposite the page which holds the plant there is printed a guide to the careful description of it, with blanks for the insertion of all particulars, and also for its classification. The frontispiece is an accurate engraving of poison ivy and poison sumach, the only plants in the northern United States which are seriously poisonous to the hand. Being brilliant and attractive, it is important that the collector should be warned beforehand, that he may avoid the danger. The book has also an introduction, with directions how to gather and press flowers. It is certainly a more desirable arrangement for its purpose than the home-made herbariums in common use.

Lecture Notes on Chemical Physiology and Pathology. By Victor C. Vaughan, M. D., Ph. D., of the University of Michigan. Second edition, revised and enlarged. Ann Arbor Publishing Company. Pp. 315.

The prompt sale of the first edition of these notes has led the author to enlarge it. Its character is expressed in its title, and it claims to be, not a complete treatise, but merely a practical guide to the working student. This book seems to be executed with care and judgment, and medical students especially who desire a thorough preparation in the physiological applications of modern chemistry will find it valuable.

THE COLOR-SENSE: ITS ORIGIN AND DEVELOPMENT. An Essay on Comparative Psychology. By GRANT ALLEN, B. A. Boston: Houghton, Osgood & Co. Pp. 282. Price, $3.50.

THIS is an interesting volume, on a topic that has come lately into prominence as one of the consequences of the theory of evolution. All pictorial art is of course based upon the color-sense in man, and it is an inquiry that can not fail to affect the theory of art whether this color-sense is an underived and always perfected faculty, or has grown through gradual stages to its present condition. That there has been a progress of taste capacity and art, founded upon the color-sense, is of course well known, but has the foundation itself been also developed? If it be admitted that it has, then there arises a new interest in the subject of color-sense as it exists among the inferior grades of animals. If color-sense and the color-perception are not to be taken as things unchangeable—if belonging to life they are a part of life, and are subject to the laws of life—then the question of the genesis of the color-faculty is legitimate, and it is proper to inquire what may have been the conditions of its origin. Professor Allen has entered upon this engaging study not merely with the enthusiasm inspired by its novelty and freshness, but in the genuine philosophic spirit, and well equipped with the scientific data for the investigation. The author's problem is, by what agencies, and under what reactions and conditions, the color-sense has originated in the grades of animal life. He finds it to be a faculty continuous throughout, but gradually unfolded and perfected, and he concludes that "the highest æsthetic products of humanity form only the last link in a chain whose first link began with the insect's selection of bright-hued blossoms."

Professor Allen combats the notion of Dr. Magnus, endorsed and popularized by Mr. Gladstone, that the color-perception of civilized man is a faculty of quite recent development, and that so lately as some three thousand years ago mankind was utterly incapable of distinguishing between violet, green, blue, and yellow. Rejecting this crude and ill-digested theory, the author remarks: "The few centuries which have rolled past during that interval form but a single pulse of the pendulum whose seconds make up the epochs of geological evolution. To me it appears rather that the color-sense of man is derived through his mammalian ancestry from a long line of anterior generations, and that its origin must be sought for in ages before a solitary quadrumanous animal had appeared upon the face of the earth." This book is an outgrowth of those studies which led the author to prepare his little volume on "Physiological Æsthetics"; but while that work was based upon human psychology, the last one relates rather to comparative psychology, or to the phenomena of mind throughout the whole animal world.

RELATION OF PHYSICAL EXERCISE TO CONSUMPTION, 16 pages; and FOUL-AIR-CONSUMPTION, 13 pages. By R. B. DAVY, M. D. Reprinted from the "Cincinnati Lancet and Observer."

IN the first of these pamphlets the author discusses the influence of muscular exercise on the more important organs of the body, and on the system in general, as affecting predispositions to pulmonary complaints, and as a means for the relief of such complaints when they have once obtained a foothold in the organism. Whether employed as a preventive or a remedy, he regards properly regulated exercise as an agent of the highest value; and among the several varieties described considers rowing as probably the best, and the health-lift as perhaps the worst, that can be adopted.

The second pamphlet is devoted to the subject of foul air as a cause of consumption, and explains how man by his habits of life and the conditions with which he surrounds himself becomes the source as well as the victim of the poison.

F. H.

THE NATIVE FLOWERS AND FERNS OF THE UNITED STATES. By THOMAS MEEHAN. Illustrated by Chromolithographs. Numbers from 12 to 24. Boston: L. Prang & Co. 50 cts. per No.

VOLUME II. of this elegant work is now complete, containing forty-eight neatly executed chromolithographs of our most interesting plants and flowers. The character of the work, text and illustrations alike, has been not only sustained but improved.

COAL, ITS HISTORY AND USES. By Professors GREEN, MIALL, THORPE, RÜCKER, and MARSHALL, of the Yorkshire College. Edited by Professor THORPE. New York: Macmillan & Co. Pp. 362. Price, $4.

THIS is a thoroughly popular book, but at the same time a fresh and instructive one. It originated in a course of lectures that were prepared for delivery in different places, by several professional gentlemen, each taking the topic with which he was most familiar. The volume has therefore something about it of authority and completeness, which give it merit. The subjects treated are "The Geology of Coal," "Coal Plants," "Animals of the Coal Measures," "The Chemistry of Coal," "Coal as a Source of Warmth," "Coal as a Source of Power," and "The Coal Question" (that is, the English question of the supply of coal), and the rates of its production and consumption. The volume is moderately illustrated, and is got up in good style.

ELEMENTS OF COMPARATIVE ANATOMY. By CARL GEGENBAUR, Professor of Anatomy and Director of the Anatomical Institute at Heidelberg. New York: Macmillan & Co. Pp. 645. Price, $7.

WE congratulate the publishers, Macmillan & Co., for their enterprise in bringing this sterling and standard Continental work to the service of English and American students. It has been demanded for a good while, and various publishers in London and New York have at divers times talked of coöperating with each other to reproduce it, but were all at last afraid of the venture. Mr. Macmillan has undertaken it alone, and we have no doubt that he will find "money in it." At all events, it is now *the* book upon the subject of comparative anatomy, for the relations of animal structures, that must be consulted by all students. Biological science has recently changed its course, by which the older treatises have become antiquated, and to meet the new requirements there must be new text-books. Lyell, when an old man, revolutionized his geology to bring it into harmony with advancing knowledge, and Gegenbaur has done the same thing with his great work on zoölogy. Dr. Lancaster, the editor, thus refers to this peculiarity of Gegenbauer's treatise: "We do not possess any modern work on comparative anatomy, properly so called; that is to say, a work in which the comparative method is put prominently forward as the guiding principle in the treatment of the results of anatomical investigation. The present work, therefore, appears to me to form a most important supplement to our existing treatises on the structure and classification of animals. It has, over and above this, a distinctive and weighty recommendation in that, throughout and without reserve, the doctrine of evolution appears as the living, moving investment of the dry bones of anatomical fact. Not only is the student thus taught to retain and accumulate his facts in relation to definite problems which are actually exercising the ingenuity of investigators, but he is encouraged and to a certain extent trained in the healthy use of his speculative faculties; in fact, the one great method by which new knowledge is attained, whether of little things or of big things—the method of observation (or experiment), directed by speculation—becomes the conscious and distinctive characteristic of his mental activity. Thus we may claim for the study of comparative anatomy, as set forth in the present work, the power of developing what is called 'common sense' into the more precisely fixed 'scientific habit' of mind."

LECTURES ON MATERIA MEDICA. By CARROLL DUNHAM, M. D. 2 vols. New York: Francis Hart & Co., 63 Murray Street. Pp. 828.

THIS is an elaborate text-book on the action of medical remedies, according to the theory of Hahnemann, and it is a treatise that will undoubtedly have weight with the professional school which it represents. Its author was Professor of Materia Medica in the New York Homœopathic Medical College, and author of "Homœopathy the Science of Therapeutics," and he is evidently recognized as a safe authority in this important branch of homœopathic medicine. The volumes are made up from his notes, observations, and memoranda, based upon close study and the experience of a wide practice. Dr. Dunham seems to have been an accomplished physician, loving his work and apt for it, and much liked by all who knew him. Of the merits of the medical system to which he adhered, our readers no doubt have their own opinions this way and that, with which

we have not the slightest inclination to meddle; but the volumes before us give evidence that their author was a learned, critical, and painstaking student in his chosen branch of professional inquiry.

Fasting Girls: Their Physiology and Pathology. By William A. Hammond, M. D. New York: G. P. Putnam's Sons. Pp. 74. Price, 75 cents.

Dr. Hammond has done excellent service in contributing this little monograph to expose a class of the grossest frauds that grow rank in the soil of popular ignorance. He has not a very high opinion of our boasted enlightenment, as we gather from the following observations: "It seems that no proposition that can be made is so absurd or impossible but that many people, ordinarily regarded as intelligent, will be found to accept it and to aid in its propagation. And hence, when it is asserted that a young lady has lived for fourteen years without food of any kind, hundreds and thousands of persons throughout the length and breadth of a civilized land at once yield their belief to the monstrous declaration." Dr. Hammond gives accounts of several cases of alleged fasting girls and ingenious deceptions, the collusions and credulities of surrounding parties, and the manner of ultimate exposure. The final chapter, on the physiology and pathology of inanition, is very instructive.

Principles of Political Economy. By William Roscher, Professor of Political Economy at the University of Leipsic, Corresponding Member of the Institute of France, Privy Councilor to his Majesty the King of Saxony. From the thirteenth (1877) German edition, with additional chapters furnished by the author, for this first English and American edition, on Paper Money, International Trade, and the Protective System; and a Preliminary Essay on the Historical Method in Political Economy (from the French), by L. Wolowski. The whole translated by John J. Lalor, A. M. 2 vols. New York: Henry Holt & Co. Pp. 929. Price, $7.

The students of economic literature owe hearty thanks to Mr. Lalor for rendering into English the learned work of Professor Roscher on political economy. It is a book of inexhaustible erudition, such as a plodding and untiring German Professor alone could produce. It abounds in curious information on a wide range of collateral topics, and runs freely into social philosophy as well as into strict economics. The notes are copious, varied, and invaluable.

Index Medicus. Monthly Classified Record of the Current Medical Literature of the World. Edited by Dr. J. S. Billings, Surgeon U. S. Army, and Dr. R. Fletcher, M. R. C. S., Eng. Monthly. New York: Leypoldt. $3 per annum.

The "Index Medicus" is a publication which can hardly fail to be heartily welcomed by the medical profession. It records the titles of *all new books* on medicine, surgery, and the collateral branches. These are classed under subject-headings, and are followed by the titles of valuable original articles in the medical journals, and the transactions of medical societies. The periodicals thus indexed comprise pretty nearly all the current medical journals and transactions of value. At the close of each yearly volume a double index of authors and subjects will be added, forming a complete bibliography of medicine during the preceding year. The "Index Medicus" contains about fifty pages of large quarto size, clearly printed on good paper. The valuable character of the work and its remarkably low price must commend it to the patronage of physicians.

The Teacher. Hints on School Management. By J. R. Blakiston, M. A., one of Her Majesty's Inspectors of Schools. New York: Macmillan & Co. Pp. 91. Price, $1.

We take it that this will prove a very helpful little work, on general schoolroom tactics, to that small circle of teachers who feel that they have any need of it, it being the business of teachers to know—and their standing, and salary, and influence in school and out of it depending upon their reputation for knowing, they can not generally afford to let it be suspected that they do not understand all about it—whatever it is. This book, by an old English school inspector, who says that his views "are the result of a personal experience of twenty-five years spent in educational work by one who feels

more every year how much he has yet to learn," proceeds upon the opposite principle. Indeed, the author goes so far as to say that when teachers are ignorant they should not have any false pride or pretension about it, but should honestly and openly admit their ignorance. His language is, "When children ask their teacher for information on subjects with which he has little or no acquaintance, he should not be ashamed of frankly owning his ignorance." This is sensible talk, and those who like it will find much more of the same sort in the volume, which will furnish many hints worth the attention of practical teachers.

Mixed Essays. By Matthew Arnold. New York: Macmillan & Co. Pp. 347. Price, $2.

The name of this author is so well and favorably known as to make any commendation of his work on our part superfluous. He deals with modern questions in the spirit of liberal, often of radical criticism, and his opening discussions on "Democracy" and on "Equality," from the point of view of an independent English thinker, will have interest for intelligent American readers. The London "Athenæum" remarks of the volume: "One feels that these essays are Mr. Arnold, and that the lesson they convey as a whole is more precious than any single principle expressed throughout them. It is the lesson of courtesy, gentleness, and toleration. The stern practical nature of life in the nineteenth century and the controversial fierceness which is at once the strength and the misfortune of Englishmen could have no better foil than this high-souled preacher, who has continually reminded us, by his own example, of the supreme value of noble conduct and high demeanor."

PUBLICATIONS RECEIVED.

Notes of a Naturalist on the Challenger. By H. N. Moseley. London and New York: Macmillan. 1879. Pp. 36. $7.50.

The Wyandotte Cave. By J. P. Stelle. Cincinnati: Moore, Wilstach & Baldwin. 1864. Pp. 85.

Etymological Dictionary of the English Language. By W. W. Skeat. Oxford: Clarendon Press. Part I., A—Dor. 1879. Pp. 176. 10*s*. 6*d*.

The Coal Trade. By F. E. Saward. New York: The Author. 1879. Pp. 73.

Practical Treatise on the Combustion of Coal. By W. M. Barr. With Plates. Indianapolis: Yohn Brothers. 1879. Pp. 315. $2.50.

Dictionary of Music and Musicians. London and New York: Macmillan. Part VI. 1879. Pp. 127.

The Art of Singing. By F. Sieber. New York: W. A. Pond & Co. Pp. 175. 1879.

L'Assommoir. By E. Zola. Philadelphia: Petersons. 1879. Pp. 380. 75 cents.

Progressive Japan. By General Le Gendre. San Francisco: A. L. Bancroft & Co. 1879. Pp. 370.

"Baptist Review." Quarterly. Cincinnati: J. R. Baumes. Vol. I. No. I. Pp. 172.

The Art of Figure-Drawing. By C. H. Weigall. New York: Putnam's Sons. 1879. Pp. 53. 50 cents.

Trial of D. M. Bennett. New York: "The Truth-Seeker." 1879. Pp. 189.

Haeckel's "Genesis of Man": a Review. By L. F. Ward. Philadelphia: E. Stern & Co. Pp. 64.

Supplementary Report on Sewer Air. By W. R. Nichols.

Sound Money. By D. A. Hawkins. Pp. 4.

Mothers' Marks. By Dr. R. Park. Pp. 13.

Ueber das von glühendem Platin ausgestrahlte Licht. Von Edward L. Nichols, Ph. D. Göttingen: Die Universitäts-Buchdruckerei von E. A. Huth. 1879. Pp. 58, with Plates.

On the Complete Series of Superficial Geological Formations in Northeastern Iowa. By W. J. McGee. From "Proceedings of the American Association for the Advancement of Science." Pp. 36.

Wall Rocks of the Bodie Auriferous Lodes. By M. Attwood. From "Proceedings of the California Geological Society." Pp. 3.

On an Improved Form of Gold-washer's Prospecting Bowl. From the "Alta California." By the same Author. Pp. 16.

Proposed Legislation on the Adulteration of Food and Medicine. By E. R. Squibb, M. D. New York: Putnam's Sons. 1879. Pp. 57. 25 cents.

All about the Plum Curculio. By J. B. Stelle. Mobile: "Register" print. 1878. Pp. 14.

Double Stars. By S. W. Burnham. From "American Journal of Science and Arts." Pp. 7.

Bigamy and Polygamy. Pp. 33.

The School Garden. By E. Schwab. New York: Holbrook & Co. 1879. Pp. 92. 50 cents.

Word and Work. By P. G. Robert. St. Louis: W. B. Chittenden. 1879. Pp. 29.

Evolution and Human Anatomy. By S. E. Chaillé. New York: Trow print. 1879. Pp. 21.

Heroes, Honors, and Horrors. Yellow Fever of 1878. By J. P. Dromgoole, M. D. Louisville, Ky.: Morton print. 1879. Pp. 176. 50 cents.

Catalogue of Plants in the Vicinity of Cincinnati. By J. F. James. Cincinnati: Barclay print. Pp. 27.

Mineral Locality in Fairfield County, Connecticut. By G. J. Brush and E. S. Dana. From "American Journal of Science and Arts." Pp. 10.

House of Representatives. Report of National Academy of Sciences. Pp. 25.

Method of Study in Social Science. By W. T. Harris. St. Louis: Jones print. Pp. 23.

POPULAR MISCELLANY.

The National Academy of Sciences.—Professor O. C. Marsh, who, after the death of Professor Joseph Henry, became acting President of the National Academy of Sciences, in his address at the annual meeting of that body, held in Washington, April 15th, presented a detailed statement of the action of the Academy with regard to the reorganization of the survey of the Territories. He also submitted a report of the progress which has been made in putting into execution Professor Newcomb's plan for determining the distance of the sun by measuring the velocity of light. Professor Marsh justly congratulates the Academy upon the unanimity with which the members adopted the scheme for reorganizing the surveys, and on its embodiment without change in a law of Congress. The Academy, in all its deliberations upon this important matter, was strictly unpartisan, and acted without respect of persons. Whether the scheme which now goes into execution will lead to better results than the old plan of many independent surveys, Professor Marsh leaves to the historian to decide. For the purpose of carrying out Professor Newcomb's plan of determining the sun's distance, the sum of five thousand dollars has been appropriated by Congress; and the work of constructing the necessary apparatus will be commenced as soon as the appropriation is available. It is hoped by those who proposed this plan that the experiments will lead to a more accurate determination of the distance of the sun than can be reached by any other method known to astronomers.

The Growth of a Continent.—The history of the growth of the European Continent, as recounted by Professor Geikie, gives an instructive illustration of the relations of geology to geography. The earliest European land, he says, appears to have existed in the north and northwest, comprising Scandinavia, Finland, and the northwest of the British area, and to have extended thence through boreal and arctic latitudes into North America. Of the height and mass of this primeval land some idea may be formed by considering the enormous bulk of the material derived from its disintegration. In the Silurian formations of the British Islands alone there is a mass of rock, worn from the land, which would form a mountain chain extending from Marseilles to the North Cape (1,800 miles), with a mean breadth of over thirty-three miles and an average height of 16,000 feet. The Silurian sea which spread across most of central Europe into Asia suffered great disturbance in some regions toward the close of the Silurian period. It was ridged up into land inclosing vast inland basins, the areas of some of which are still traceable across the British Islands to Scandinavia and the west of Russia. An interesting series of geographical changes can be traced, during which the lakes of the Old Red Sandstone were effaced, the sea that gradually overspread most of Europe was finally silted up, and the lagoons and marshes came to be densely crowded with the vegetation to which we owe our coal-seams. Later terrestrial movements led to the formation of a series of bitter lakes across the heart of Europe, like those now existing in the southeast of Russia. Successive depressions and elevations brought the open sea again and again across the continent, and gave rise to the accumulation of the rocks of which most of the present surface consists. In these movements the growth of the Alps and other dominant lines of elevation can be more or less distinctly traced. It was at the close of the Eocene period, however, that the great disturbances took place to which the European mountains chiefly owe their present dimensions. In the Alps we see how these movements led to the crumpling up and inversion of vast piles of solid rock, not older in geological position than the soft clay which underlies London. Considerable additional upheaval in Miocene times affected the Alpine ridges, while, in still later ages, the Italian Peninsula was broadened by the uprise of its sub-Apennine ranges. The proofs of successive periods of volcanic activity during this long series of geographical revolutions are many and varied. So, too, is the evidence for the appearance and disappearance of successive floras and faunas, each no doubt seeming at the time of its existence to possess the same aspect of antiquity and prospect of endurance which we natu-

rally associate with those of our own time. The law of progress has been dominant among plants and animals, and not less upon the surface of the planet which they inhabit. It is the province of the biologist to trace the one series of changes, of the geologist to investigate the other. The geographer gathers from both the data which enable him to connect the present aspects of nature with those out of which they have arisen.

Storms and Neuralgia.—At the April meeting of the National Academy of Sciences, Dr. S. Weir Mitchell read a paper on "The Relation of Neuralgic Pain to Storms and the Earth's Magnetism." The interesting observations here recorded were made by Dr. Mitchell in conjunction with Captain Catlin, of the United States Army, who lost a leg during the war, and who, since that time, has suffered from traumatic neuralgia, sometimes in the heel, but more frequently in the toes, of the lost foot. The hourly observations cover a period of five years. For the first quarters of these five years there were 2,471 hours of pain; for the second quarters, 2,102 hours; for the third quarters, 2,056 hours; and for the last quarters, 2,221 hours. The greatest number of hours of pain is in January, February, and March; and the least in the third quarters, July, August, and September. During these five years, while the sun was south of the equator, there were 4,692 hours of pain, against 4,158 hours while it was north of the equator; and the greatest amount of pain was in the quarters beginning with the winter solstice, and the least was in those beginning with the summer solstice. The average duration of the attacks for the first quarters was 22 hours, and for the third quarters only 17·9 hours. By taking the four years ending January 1, 1879, it is found that, of the 537 storms charted by the Signal Bureau, 298 belong to the two winter quarters, against 239 for the summer quarters. Hence we have the ratio of the number of storms of the winter quarters and summer quarters corresponding to the ratio of the amounts of neuralgia for these respective periods, and the ratio of average duration of each attack for the same time corresponds closely with the ratio of the respective total amounts of neuralgia for the same periods. The average distance of the storm-center at the beginning of the neuralgia attacks was 680 miles. Storms coming from the Pacific coast are felt farthest off, while storms along the Atlantic coast are associated with milder forms of neuralgia, and are not felt until the storm-center is nearer. Rain is not essential in the production of neuralgia. It was found that the severest neuralgic attacks of the year were those accompanying the first snows of November and December. Every storm, as it sweeps across the continent, consists of a vast rain area, at the center of which is a moving space of greatest barometric depression, known as the storm-center, along which the storm moves like a bead on a thread. The rain usually precedes this by 550 to 600 miles; but before and around the rain lies a belt which may be called the neuralgic margin of the storm, and which precedes the rain about 150 miles. This fact is very deceptive, because the sufferer may be on the far edge of the storm-basin of barometric depression, and see nothing of the rain, yet have pain due to the storm.

Physiological Action of Aconite.—From certain experimental inquiries into the physiological action of aconite and its alkaloid, *aconitia*, Dr. G. H. Mackenzie concludes that these drugs act primarily on the respiration by their influence on the respiratory center and peripheral sensory branches of the vagus nerve. They have no direct action on the heart, and only affect that organ secondarily through the medium of the lungs. Their action on the nervous system consists in firstly irritating and secondly paralyzing the peripheral sensory nerves and posterior roots of the spinal nerves. They have no direct action on the brain or the vaso-motor nerves. They increase the irritability of the peripheral motor nerves, and of the motor columns of the cord. They do not induce muscular paralysis, but, on the contrary, increase the irritability of voluntary muscle. They induce convulsions mainly through their augmenting the irritability of the anterior column of the cord, the motor nerves, and muscles. They firstly increase and secondly diminish temperature. Death ensues from asphyxia and respiratory collapse.

Curiosities of Nervousness.—An interesting book might be made out of the curiosities of nervousness from a contemporary standpoint. The elder Disraeli has somewhere a chapter on the subject; but, if our memory serves us correctly, his instances trench rather upon the hysterical conditions, the monomanias, the wild fanciful delusions of the disordered imagination, than upon the prosaic features of the distemper. He instances men who could not bear the sight of old women, and fainted dead away if a grandmother showed herself; others who, if they heard a rat in the wall, took it for a ghost and got up and prayed fervently; and such things. The present age furnishes more rational imaginings, born of the daily papers, emphasized by indigestion, and riveted by the surprising eloquence of the diurnal quidnuncs. For instance, there are plenty of people living at this moment who would warmly refuse to get into bed before looking under it to make sure that no man lay there. There are others who pass the night in constant fear of fire; who, before they withdraw to their bedchambers, carefully rake out every fireplace in the house, turn off the gas, inspect every room, knock on the servants' doors and inquire through the key-holes if their candles are out; and after all this bother go to bed and lie awake until the dawn with their bedroom doors ajar, sniffing at imaginary fumes of burning, and ready to spring out and go raving mad should anything like a cry be raised—for these people never make any serious provision against fire should fire come. There are others, again, who will lie night after night in expectation of burglars. A distant footfall will court them to the window, where, cautiously pulling aside the blind by the breadth of a nose (giving scope to one eye), they will peer into the gloom and mistake some shadow for the figure of a man (wrapped in an overcoat and with a horse-pistol in every pocket), intent upon the particular window whence he is being watched. Others will be kept awake by the song of the wind about the casement, or in the empty rooms around, confounding these natural sounds with the murmur of human voices in the pantry, or on the landing just outside.

These are some of the hundred night fears beyond an ordinary imagination to express. But there are daylight fears as numerous, if not always so agonizing. What words can convey the horror felt by a certain kind of nervous people who, making a journey on a railway, are suddenly brought to a stand in a tunnel? Nothing can comfort them. Their heads shoot through the windows, their cries lacerate the gloom, and the reassuring shouts of the guard only aggravate their fright and provoke fresh yells for immediate release. Or take the mental condition of another kind of nervous persons at sea. Every roll of the vessel means imminent death. The carrying away of a water-cask, the momentary stoppage of the engines, the cry of a man on the lookout, the escape of a sail from the gaskets that confine it to the yard, and its consequent bellowing upon the gale, the abrupt shipping of a sea, nay, the tumbling of a steward down a ladder, or the fall and smash of a few plates from the leaning saloon table, will strike an indescribable horror, and lead to no end of convulsive clingings and mumblings of prayer. Indeed, it would be possible to fill every page in this journal with a catalogue of the imaginative afflictions under which nervous people labor. Old Doctor Johnson, going back to touch an omitted post, typifies a host of numerous disorders which need not be mistaken for superstitions, and which assume a vast number of shapes among us in these days. Take a pavement full of people with a ladder across it from the house-top to the curbstone. How many of the passengers will wade into the mud of the road to save themselves from passing under that ladder? The proportion of the nervous people in the world will be happily indicated by such an example. Of every hundred persons, we question if ten would, without hesitation, pass under that ladder. When a man refuses to make his will, because he fears that by doing so he will be hastening his death, are we not to attribute his cowardice to the nerves? It is a mere convenient apology to call such misgivings superstitions. No one would hope to cure a priest's faith in a winking Madonna by a course of quinine; and superstitions of the real sort are assuredly not to be corrected by medical treatment. But our latter-day nerves *are* to be dealt with, and

a good many uncomfortable horrors taken out of our minds, by the judicious doctor. —"Mayfair."

A Botanical Usurper.—One of the most curious instances on record of the invasion of a country by a plant of foreign origin, and the extermination by it of indigenous species, is seen in the history of the mango-tree in the island of Jamaica, as recounted by Sir Joseph Hooker. It reminds us of the accounts of captured tribes which after being carried into their conquerors' country have so increased and multiplied as eventually to dispossess and supplant their captors. In 1782 Admiral Rodney captured a French ship bound for San Domingo from Bourbon, with living plants of the cinnamon, jack-fruit, and mango, sent to the Botanic Garden of the former island by that of the latter. The prizes were presented by the Admiral to the Jamaica Botanic Garden. There the cinnamon was carefully fostered, but proved to be difficult of culture in the island; while the mango, which was neglected, became in eleven years as common as the orange, spreading over lowlands and mountains from the sea-level to 5,000 feet above it. On the abolition of slavery immense tracts of land, especially coffee plantations, relapsed to a state of nature, and, the mango being a favorite fruit with the blacks, its stones were flung about everywhere, giving rise to groves along the roadsides and around the settlements; and the fruit of these again, rolling down hill, gave rise to forests in the valleys. The effect of this spread of the mango, Sir Joseph Hooker adds, has been to cover hundreds of thousands of acres, and to ameliorate the climate of what were dry and barren districts by producing moisture and shade, and by retaining the rainfalls that had previously evaporated; all this, besides affording food for several months of the year to both negroes and horses.

Explorations in Central Africa.—Two French travelers, M. Savarguan de Brazza and Dr. Ballay, have returned to Paris after a three years' exploration of the Ogowé (or Ogobai) River. In August, 1875, the travelers left Lambarene, the extreme limit of the European factories, and, escorted by twelve Laptots, or native African soldiers of the French colony of Senegal, explored the river to its sources. One result of the expedition is to prove that the Ogowé does not rise in an interior lake. The river may be divided into three nearly equal parts—the upper, the middle, and the lower. The middle follows an almost straight east and west course just south of the equator; the two others incline about a degree and a half toward the south. The first halt was made at Lopé, a large village on the upper Ogowé. M. de Brazza penetrated into the country of those noble cannibals, the Fans, with whom he entered into friendly relations, and succeeded in reaching Dumé, a position considerably advanced on the upper river. He suffered seriously in this journey, and on his return had to let his companions advance to Dumé without him; he was only able to rejoin them in April, 1877. Through great hardships and dangers they made their way to the Pubara Fall, above which the Ogowé becomes an inconsiderable stream.

After a few days' rest here, the explorers left the basin of the Ogowé in March, 1878, to penetrate still farther into the interior. They traversed successively the territories of the Ondumbo, the Umbeté, and the Bateké, suffering greatly on the way from both hunger and thirst, for the country was devastated by famine. A stream running east, the N'Gambo, led the explorers to an important river, the Alima, 500 feet wide and sixteen feet deep, apparently an affluent of the Congo. In attempting to descend the Alima they had to run the gantlet between banks lined with hostile savages. They quitted the river and marched northward, crossing many watercourses flowing eastward. They suffered so much from hunger that the expedition had to be divided, Dr. Ballay and one of the attendants being sent back to the Ogowé. M. de Brazza went some distance farther northward, when hunger and suffering compelled him also to retreat, and he rejoined his comrade in September. On November 30th the whole party reached the French settlement at the Gaboon.

From Corisco Bay, on the west coast of Africa, and a little north of the mouth of the Gaboon, comes intelligence of certain important explorations made by Hugo de Koppenfels, who reports that he ascended the Muni, the Noya, the Balinji, and the

Tambuni to the first falls. In the Crystal Mountains he fell in with tribes absolutely unknown up to the present, or who at least had not been seen by whites with rare exceptions—the Etemo, the Manga, the Otonto, and the Toko. These people are described as very inoffensive; they regarded their white visitor as a curious animal, and had a certain fear of him. When he asked them to accompany him into the interior they agreed readily. They are frightfully poor, being obliged to give up planting on account of the ravages of elephants and gorillas, which are very numerous and daring. Not a single night passed, the traveler states, that he did not hear those animals ravaging around the villages, which are mostly very large. As soon as the animals are known to be near, the whole village is on foot endeavoring to frighten them away by shouting. In these nocturnal expeditions, in which the explorer took part, he noticed that the head man of the village addressed a speech to the elephants, and that in this speech his own name was pronounced. He was told that the elephants were threatened to be handed over to him, and that, if they did not fly at once, they would be visited on the morrow, and the white man would kill them. If the elephant seizes a plant with its trunk, the people immediately raise a dreadful, plaintive howling, and the principal orator addresses, in a lamentable voice, supplications to the enormous brute.

The Annual "Outing."—That the change of scene and air secured by an annual "outing" is beneficial to health can not be doubted. The relief afforded counts for much, the opening up of new sources of energy counts for more, in the sum of advantages gained. Meanwhile, not only will the profit be small, but the result questionable, unless the relief and the sense of freshness are shared by mind and body alike. In a word, perfect absence of *worry* is essential to the full enjoyment and restorative action of the holiday. This is just what the majority of persons, particularly the heads of families, forget, for themselves and those around them. A jaded mind needs rest quite as much as a weary body, and neither the one nor the other can obtain the sort of rest which is essential to a complete renewal of strength without the awakening of new interests. The simple cessation of work may in some few instances give relief, but much more than this is necessary for the recovery of health and renewal of energy when mind and body are exhausted by long-continued or monotonous toil, or domestic duty. It follows that, in the choice of a locality and in the manner of conducting the trip, the inclination should be consulted not less than general convenience. It is too much the practice to make a toil of a pleasure, and create occasions of annoyance in the course of the annual holiday. Everything should be planned to leave the mind free as regards the obligations of home duty, and enable it to share the advantages of the change bestowed on the body. There is plenty of thought for the physical part of man's nature; it may not be unreasonable to put in a plea for the consideration of his needs as a being endowed with a mental part, which is apt to be overmuch burdened with responsibility and harassed by many cares. The annual outing will be incomparably more enjoyable, and productive of lasting benefit, if these needs of the mind are considered, instead of being systematically overlooked. People go away anxious, and return to mourn over the smallness of the benefit they have received. They took their worries with them, and might almost as well have staid at home.—*Lancet.*

What is a Poison?—Under the fanciful title of "The Keys of Death," we find in the "Monthly Journal of Science" a very interesting article on the subject of poisons. The author asks, in the first place, what is a poison, but science, he holds, is not yet qualified to give an answer. Certain physiologists have concluded that whatever is poisonous in large doses must also be poisonous in the minutest. But it is easy to give instances where, if the reagents employed are less in proportion, or weaker than the required standard, we obtain, not a smaller quantity of the product sought for, but a substance totally different. Oxygen is a case in point: diluted, it sustains life; pure, it destroys it. So with sulphuric acid. Mixed largely with water, it is a refreshing, tonic beverage; in the concentrated state it destroys all parts of the system which it touch-

es. Again, a definition of poisons has been based on the fact that while certain articles of food undergo decomposition in the stomach, poisons do not. Then water is a poison, for it does not suffer decomposition in the system.

But, turning aside from these definitions, we find included under the general name of "poisons" two very different classes of bodies, viz., "germs" which, when absorbed by an animal, bring on such diseases as rabies, small-pox, cholera, etc.—in short, the zymotic diseases; and, in the second place, the true poisons, such as arsenic, strychnine, aconitine, etc. These latter substances are well-defined chemical individuals. When introduced into the system they set up morbid action almost immediately, and if the dose be sufficient the symptoms go on increasing in violence till death ensues. A characteristic feature is that their noxious power may be decreased or even extinguished by dilution.

The other class, however, the ferments, are not definite chemical principles, capable of being isolated, of entering into combination with other bodies, and of being separated again; they are, so far as we know, living organisms of low type.

The immunity of certain animals from the action of poisons which are fatal to others is remarkable. This difference of susceptibility often exists between individuals of the same species, being developed in some cases by natural selection, in others by habituation. The author of the paper in the "Journal of Science" gives the following list of caterpillars which feed on poisonous plants: *Gonopteryx rhamni*, on *Rhamnus catharticus; Thats polyxena*, on species of *Aristolochia; Danais archippus* and *chrysippus*, upon various *Asclepiads; Deilephila galii, Nicea*, and *Euphorbiæ*, on species of *Euphorbia; Chærocampa nerii*, on the oleander; *Sphinx polia cappa*, on staves-acre; *Heliothisa armigera*, on tobacco; and *Chrysoptera moneta*, on monk's-hood.

A New Electric Pen.—In the "Monde de la Science" is a description of an improved electric pen, much cheaper than Edison's, and not so fatiguing to the operator; the inventor would appear to be an Englishman, Wentworth L. Scott. The pen consists of an open glass tube drawn out to a point at one end, where there is a minute orifice. Within the tube is a copper wire, to which a fine platinum point is soldered toward the lower end of the pen. This copper wire is held in the middle of the tube by means of a cork stopper at the larger end (the upper end of the pen). The point of platinum should just reach the tip of the pen. To work the instrument the copper wire is connected with one of the poles of a Ruhmkorff coil. The other pole is connected with a zinc plate, on which the paper is to be laid. The circuit is now closed, and so soon as the current flows it causes the interrupter of the Ruhmkorff coil to vibrate. The pen is then made to move over the paper, as in writing, care being taken only to touch the glass tube, for fear of electric shocks, and electric sparks are seen to pass with great rapidity between the point of the pen and the paper. On holding up the paper between the eye and the light, the track of the pen is seen to consist of minute perforations, like those produced by Edison's electric pen. The instrument is as light as a common pen. The cost of the whole apparatus is trifling, about eighteen francs.

Alum as an Adulterant of Baking-Powders.—Dr. Henry A. Mott, Jr., employed as chemist for the Indian Department, having made analyses of different baking-powders, publishes in the "Scientific American" as the result of his investigations the statement that at least fifty per cent. of the many baking-powders examined by him were grossly adulterated. Dr. Mott found that the injurious powders are composed of alum and bicarbonate of soda, oftentimes containing also terra alba, insoluble phosphate of lime, etc. The best powders are composed of bitartrate of potash (cream of tartar), tartaric acid, carbonate of ammonia, and bicarbonate of soda, held together by a little starch to prevent decomposition. The injurious effects of alum on the digestive organs have been pointed out by eminent chemists and physicians: it produces dyspepsia, constipation, vomiting, griping; it is a powerful astringent, acting chemically on the tissues. Says Dumas, the French chemist: "It is to be feared that this salt (alum) exerts a deadly action by its daily introduction into the

stomach, especially in persons of weak constitution." Liebig condemns the use of alum in bread-making on this ground among others, that it combines with the soluble phosphates, forming insoluble salts, and thus the phosphorus of the grain is lost to the system. Dr. Mott's paper exhibits as follows the results of the analysis of four brands of baking-powder:

DOOLEY'S STANDARD BAKING-POWDER.

Burnt alum	26·45 per cent.
Bicarbonate of soda	24·17 " "
Sesquicarbonate of ammonia	2·31 " "
Cream of tartar	None
Starch	47·07 " "
	100·00

PATAPSCO BAKING-POWDER.

Burnt alum	20·03 per cent.
Bicarbonate of soda	22·80 " "
Cream of tartar	None
Starch	57·17 " "
	100·00

CHARM BAKING-POWDER.

Burnt alum	30·06 per cent.
Bicarbonate of soda	31·82 " "
Cream of tartar	None
Starch	38·12 " "
	100·00

BAKING-POWDER MANUFACTURED BY C. E. ANDREWS & CO., MILWAUKEE, WIS.

Burnt alum	22·53 per cent.
Bicarbonate of soda	21·79 " "
Cream of tartar	None
Starch	55·68 " "
	100·00

Adulteration of Food and Drugs.—Some astounding facts with regard to the adulteration of articles of food and medicine are brought together by the "Medical and Surgical Reporter," being taken from various medical and pharmaceutical periodicals. Thus we are told that in New England several mills are engaged in grinding white stone into powder for purposes of adulteration, three grades of powder being ground at some of the mills, viz., a soda grade, a sugar grade, and a flour grade. A Boston chemist has found seventy-five per cent. of terra alba in a sample of cream-tartar; and most of our confectionery contains thirty-three per cent. or more of this substance. These and many other adulterations of materials used in the preparation of food have been pointed out in "The Sanitarian." The adulteration of drugs is practiced to such an extent that "in some localities a conscientious pharmacist is hardly able to earn a livelihood, owing to the mean and dishonest competition which surrounds him." "Salicine," writes a physician in a Louisville medical journal, "is heavily adulterated by mixing it with cinchonidia sulphate." Again, the editor of "The Pharmacist" sought in vain among the druggists of Chicago for black sulphuret of antimony. He obtained what purported to be that substance at seven wholesale drug-houses; but not a trace of antimony was to be found in any of the samples! Analysis showed it to be in most cases simply marble-dust blackened with soot.

Pinto's Trip across Southern Africa.—A telegram received at Lisbon, on March 11th, announced the arrival of Major Serpa Pinto on the eastern coast of Africa, after having traversed the continent from Benguela on the west coast. We take from "Das Ausland" the following account of Major Pinto's memorable journey: On November 12, 1877, he set out from Benguela, in Lower Guinea (about latitude 13° south), and on March 8, 1878, entered the negro kingdom of Bihé, where he had his first fight with the natives. He devoted himself particularly to the exploration of the upper and middle Zambesi, that grand stream which, lying some ten degrees of latitude south of the Congo, like that river traverses almost the entire breadth of the African Continent. If it is the purpose of Portugal to found in equatorial Africa another Brazil, the most accurate knowledge of the course of the Zambesi must be of the utmost importance to her. Portugal controls the coast on both sides, the western and the eastern, in equatorial South Africa, and, if she succeeds in establishing communication between these two coasts by means of the Zambesi, the new colonial empire would be a fact. This project is favored by the wealth of gold found in the lower Zambesi regions, and it is surely no mere accident that latterly the Government has been making large concessions to English and Portuguese companies. Incidentally Major Pinto appears to have revealed the mystery of the Cubango, a stream whose sources are not

very distant from those of the Zambesi, but which soon takes a north and south direction. Only the upper course of this stream was hitherto known to Europeans. It was supposed that farther down it turned to the west and flowed into the Atlantic as the Owambo or Cunene. Pinto has now probably made the discovery that the Cubango is a tributary of the Zambesi. However this may be, our knowledge of the interior of Africa has been considerably enlarged by Pinto's journey.

On reaching the Transvaal Territory the explorer sent the following dispatch to the King of Portugal: "I am now six days' journey from the Indian Ocean, and on the point of completing my march across Africa from the west coast. I have struggled against hunger and thirst, wild beasts, savages, floods, and drought, and have happily surmounted all these obstacles. My records are safe, and consist of twenty geographical charts, three volumes of important coördinates, meteorological notes, three volumes of sketches, and a voluminous journal. I have lost several men. Complete study of the upper Zambesi, sixty-two cataracts and rapids. Plan of the cataracts. The natives fierce; unceasing wars. The secret of the Cubango. SERPA PINTO."

Strength of Hard and Soft Steel.—It has hitherto been supposed that a soft bar of steel can longer resist the disintegrating action of strains and shocks than a hard one, but experiments made by W. Metcalf, of Pittsburg, appear to prove the contrary to be the fact. His attention was first called to this matter by the constant breaking of steam-hammer piston-rods. Made of ordinary steel, they lasted but six months, an iron rod lasting but half as long. Then lower and lower steels were tried, and broke in about five months. In an emergency, a rod of comparatively high steel was employed, and this, which it was supposed could not serve for more than a week or two, held out for more than two years. This result led Mr. Metcalf to investigate the whole subject systematically, and a lot of small steel connecting-rods were tested in a special machine. The test required was, that a machine should run $4\frac{1}{2}$ hours at a rate of 1,200 revolutions per minute, unloaded, before the connecting-rod broke. These rods were unforged in the middle, and consisted of a piece of round bar with a head welded on each end. "The mode of rupture was," says Mr. Metcalf, "as a rule, the same in all cases; the rod heated at the middle, where the vibrations met, as they were imparted by rotary motion at one end, and by reciprocating motion at the other, and by alternating strains of compression and extension. In some cases the rod became slightly red-hot at the middle before rupture. After heating, the next thing observed was the raising or loosening of the surface scale of the middle. Soon after this, rupture began, first at the surface and gradually extending to the center. The breaking was gradual in every case, no piece breaking suddenly, even of the highest steel. The first trial was with ·53 carbon steel: mean time of six trials, 2 hours $9\frac{1}{3}$ minutes. Second trial, ·65 carbon steel: mean time of six trials, 2 hours $57\frac{1}{2}$ minutes. Third trial, ·85 carbon steel: mean time of three trials, 9 hours 45 minutes, and the trials were stopped." A set of twelve connecting-rods, made from special ingots, was then prepared. These were tested with the following results:

The ·30 C ran 1 hour 21 minutes, heated and bent before breaking.

The ·49 ran 1 hour 28 minutes.

The ·53 ran 4 hours 57 minutes, broke without heating.

The ·65 ran 3 hours 50 minutes, broke at weld where imperfect.

The ·80 ran 5 hours 40 minutes.

The ·84 ran 18 hours.

·87 C broke in weld near the end.

·96 C ran 4 hours 55 minutes, and the machine broke down.

The whole twelve were not tested, because the machine was needed for other works, and, when Mr. Metcalf returned to complete the experiment, it was discovered that the foreman of the shop had picked up the unbroken specimens, put them into machines, and sent them off. Enough was done, however, to show that the maximum of strength to resist vibration was not found among the ductile steels. Mr. Metcalf gives some other data concerning the performance of steel suspension-rods in a bridge that corroborate his views, which are practically novel.

NOTES.

In a cave near Decatur, Ohio, were recently found, imbedded in ashes, fragments of human bones, pieces of pottery, also bones of wild animals, shells, etc. According to a correspondent of the "Marietta Register," the human jawbones found in this cave are very large, and have the teeth well preserved. They have one tooth back of the "wisdom-tooth." All the long bones were broken or split—a probable indication of cannibal practices.

A curious fact in the history of the yellow-fever epidemic last year, in New Orleans was, that in the Fourth District, the death-rate of males was seventy per cent. greater than that of females, though the sanitary census of 1877 showed that the female population of the district exceeded the male by 1,261. The comparative immunity of the negro race appears from the fact that while the white population of the district (29,482 souls) lost 569 persons by death, the black population (6,883 souls) lost only 29. If the negroes had died in the same ratio as the whites, they would have lost about 130.

As an illustration of the sudden extreme alternations of temperature in northern Dakota and Montana, Dr. P. F. Harvey, U. S. Army, states that in August, 1876, while on duty with an expedition against hostile Indians, he saw the thermometer record 116° Fahr. in the shade at the mouth of the Rosebud River; thirty-six hours afterward, the temperature had fallen to very nearly the freezing-point; and, on the morning of the second day following, he scraped hoar-frost from a log in front of his tent.

The "Examiner" notes an extraordinary decrease in the number of students of theology at the German universities. The decrease is so great that in several states there has been an insufficiency of candidates for the pulpit. Until now Schleswig-Holstein was an extensive nursery of theologians, but there also a falling off by nearly 40 per cent. has recently occurred. At Kiel there are at present 24, at other German universities 28 students of theology from Schleswig-Holstein—altogether 52. Six years ago there were still 90 of them, while fifty years ago there were no less than 168 students of theology at Kiel alone, almost all of them Schleswig-Holsteiners.

Underground telegraph cables are now completed between Berlin and Cologne, Cologne and Elberfeld, Frankfort and Strasburg, and Hamburg and Cuxhaven; the total length of these lines is 1,554 miles, and the cost about $3,000,000.

The suggestion is made in "Dingler's Polytechnisches Journal" that air for ventilation be drawn into buildings through tubes sunk about three metres in the ground (say ten feet). By this means it would in winter be warmed 15° or 16° Fahr., and in summer cooled 20° to 23° Fahr.

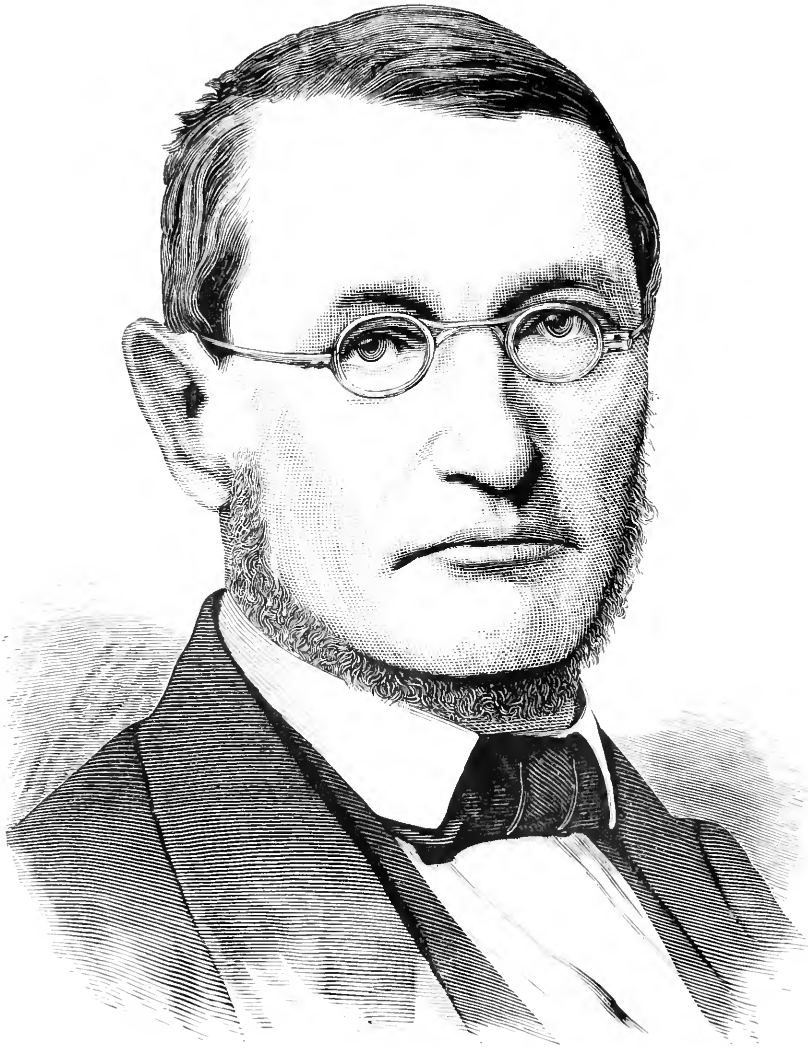
Peter Le Neve Foster, for twenty-five years Secretary of the London Society of Arts, died recently, at the age of seventy years. A lawyer by profession, Mr. Foster took a lively interest in various departments of science. He was one of the first to practice, as a scientific amateur, the art of photography, and was a frequent contributor of articles on that subject to periodicals and cyclopædias. He was President of the Queckett Microscopical Club for one year, and from 1863 to 1866 served on the Council of the British Association.

The London Geological Society has awarded the Bigsby Medal to Professor E. D. Cope, of Philadelphia, in recognition of his services to the science of paleontology.

In Brazil the coffee plantations, like the vineyards in France, are threatened with destruction by the ravages of a minute parasite. The roots of the plants are found covered with knots and swellings like those seen on the roots of the grapevine infested by the phylloxera. In these swellings are found minute nematode worms one fourth of a millimetre in length when fully developed. A single root often contains as many as fifty million of these parasites.

The larva of the tapeworm known as *Tænia solium* comes from "measly" pork, and the mature worm has a head bearing a crown of hooks. *Tænia mediocanellata* is derived from beef and mutton; it has a larger head, which is unarmed. It has commonly been supposed that the former species is more frequently found in human subjects than the latter, but Professor Leidy is of the contrary opinion. Thorough cooking of meats is a sure preventive of the development of these unwelcome entozoa.

An apparatus, the invention of an American, for carrying a line to a vessel in distress was lately tested in England. It consists of a projectile weighing $12\frac{1}{2}$ pounds, the necessary line included. This projectile is placed in a gun, the wrong or heavy end first, and on leaving the muzzle, at once turns over, the front end becoming the rear. In shape it is an elongated shell $12\frac{1}{2}$ inches long, $3\frac{1}{4}$ inches in diameter, carrying a line tightly coiled within, which it pays out as it flies through the air. At 22° elevation, the distances reached by the projectile were 389, 448, and 507 yards, the deviation of the shot and line from the target being $4\frac{2}{5}$, nine, and eight yards respectively.



JULIUS ROBERT MAYER.

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WASTED FORCES.*

By WILLIAM H. WAHL, Ph. D.

THOSE inventions are deserving of special honor, and generally receive the most substantial recognition, which develop new industries or utilize waste products.

The glycerine industry, which has attained colossal proportions, is a notable illustration of a great manufacture based entirely upon the saving of what until lately was a waste product of the soap-boiler. As even more important, I may mention the industries connected with the manufacture of aniline dyes and artificial madder from the refuse coal-tar that was formerly the curse and nuisance of the gas-works. Old boots and shoes and leather waste are turned to good account by the chemical manufacturer in producing the cyanides, ferro and ferrid cyanides, so indispensable in color-printing and photography. Of the carcasses of slaughtered animals, not a scrap or morsel is allowed to go to waste, as you are well aware; and even the waste blood of the abattoir is used by the sugar-refiner and the manufacturer of albumen. Sawdust mixed with blood, or some other agglutinative substance, and compressed by powerful pressure in heated dies, is formed into door-knobs, hardware and furniture trimmings, buttons, and a thousand useful and decorative articles; or, as is the case with the spent bark of the tanneries, it is utilized for fuel under steam-boilers. Oyster-shells, of which our barbarous progenitors of ages ago made the shell-mounds that delight the soul of the anthropologist of to-day, are burned to lime; the waste of the linseed-oil manufacturers is eagerly sought after as food for cattle; the waste ashes of wood-fires are leached for potash; river-mud is mingled with chalk, and burned and ground to

* An address delivered at the opening of the spring course of lectures of the Wagner Free Institute of Science, Philadelphia, March 1, 1879.

make the famous Portland cement; and the ruthless hand of Utilitarianism has not even respected the brickbat, that had served from time immemorial only to crack the heads of opposing factions, but grinds it up to make cement with lime. The finest glue size is made from the waste of parchment skins. The waste gases of the blast-furnace are now utilized to heat the blast, to generate the steam that drives the engine that makes the blast, to hoist ores, drive machinery, etc.; and even the slag, that has served for years only to decorate the hillsides, is now cast into paving and building blocks, or granulated to make building sand, or ground for cement, or mixed with suitable chemicals and turned into the commoner grades of glass, or blown by a jet of steam into the finest filaments to form the curious substance called mineral wool, now largely used as a non-conductor of heat upon steam-pipes, boilers, roofs, etc., etc.

So, too, the enormous hills of anthracite-coal dirt, that in the coal regions of our State have for years borne silent but eloquent testimony to the crudity and wastefulness of our methods of mining coal, now bid fair soon to disappear beneath boilers supplied with ingenious dust-burning devices, or in the form of lumps of artificial fuel. Even the anthracite-coal deposits, now so enormously valuable, were a few years ago but so many layers of black stone, unappreciated and valueless. The waste heat of the lime-kiln is made to generate steam, and warm immense public buildings in England and on the Continent; and the "exhaust" of the steam-engine is made to do service in heating the water fed into the boiler.

I might multiply examples like the above almost indefinitely, to show how, with the most beneficent results, the genius of invention has enabled us to reap advantages where none were supposed to exist, or where, if they were suspected, they were undervalued or simply neglected.

And now, having briefly shown, by a few typical examples, what modern invention has done and is doing to utilize the waste products of nature and of the arts, I shall invite you to consider with me whether there are not waste forces in nature that can and should be turned to useful account, or to vastly better account than we are now putting them; and whether we must not plead guilty to the crime of neglecting to avail ourselves of exhaustless and incalculable stores of power that simply wait to do our bidding.

Before I pass to the consideration of what I have called the "*Waste Forces of Nature*"—by which I mean to designate such of the natural powers as the world of industry has thus far passed over altogether—it will be instructive for us to consider whether we are doing what we ought to do with those that are used, and whether, with all the inventions of our skilled mechanics and engineers, the actual practical results that we obtain from the various sources of power used in the industries do not fall far below what theory declares it to

be possible to attain. Suppose we take steam, the almost universal motive power of to-day, as an example, and put the inquiries, What ought we to get out of it and what do we get out of it? And when I am through, I think that many of my hearers, who have heretofore entertained the belief that steam-engineering was a field that had been so thoroughly worked up that but little remained to be accomplished in the direction of increasing the duty of our steam-motors, will be willing to acknowledge themselves mistaken.

To get at the practical duty of a steam-engine, we must begin with the source of the power, the steam-generator—popularly and most inappropriately called the steam-boiler; and, as the source and origin of the power generated in the boiler and directly traceable to the combustion of the fuel, it is evident that we must begin with that. Let us inquire, therefore, what power we *ought* to get from a perfect steam-engine burning pure coal, and then compare it with what we do get in the best steam-engine practice of to-day.

To understand the deductions I shall shortly make in getting at this comparison between theory and practice, I prefer to invite you to follow me through a few theoretical considerations, rather than ask you to accept the conclusions simply on my bare assertion.

It has long been known that a definite relation exists between the quantity of heat developed in a given operation and the quantity of mechanical force (manifested as work) that could be obtained from that heat. The absolute nature of this equivalency is tacitly recognized, though perhaps imperfectly comprehended in the practice of every branch of industry employing heat as a source of power; for it is this fact which establishes the dimensions of the steam-boiler, and the several proportions of the engine to do the work required of it. The steam-engine, in simple language, is simply an apparatus for turning heat into work; and it is, therefore, quite possible to express the value of a given quantity of the form of energy we call heat in terms of mechanical energy that we call "work"; and scientific investigation has established an admirable unit for this comparison in the "foot-pound"—that is, the force required to raise a pound weight to the height of one foot.

Now, to estimate the value of heat in terms of work, it was found necessary to determine the amount of mechanical force necessary to raise the sensible heat of one pound of water one degree in temperature. This amount has been carefully determined by several eminent *savants*, and has been given the name of the "mechanical equivalent of heat." The value of this constant has been found to be 772 foot-pounds—that is to say, the mechanical energy possessed by a body weighing one pound, after falling from a height of 772 feet, would, if it could all be converted into the form of energy we call heat, be exactly sufficient to raise the temperature of one pound of water 1° Fahr. (where the centigrade thermometer is employed, this constant

will have a value of $772 \times 1{\cdot}8 = 1{,}390$ foot-pounds). Now, this much having been gained in fixing the principle of our calculations, let us go back to our steam-boiler, and to the coal we feed it with. It has been experimentally determined that, if the entire quantity of heat given off during the burning of one pound of pure coal could be applied without loss to heating water, it would suffice to raise the temperature of one pound of water 7,900° C.; or, what is the same thing, differently stated, it would be sufficient to raise the temperature of 7,900 pounds of water one degree. The possible mechanical duty of the "theoretically perfect" steam-engine is found by simply multiplying the quantity which expresses the thermal equivalent of coal by the quantity which expresses the mechanical equivalent of heat, and the result would be the true value of one pound of coal burned in the boiler in "foot-pounds." Performing this simple arithmetical operation, we obtain ($7{,}900 \times 1{,}390 =$) 10,980,000 foot-pounds; or, to put it more simply, suppose we convert these foot-pounds into horse-power, which we can do by another simple arithmetical operation of dividing them by 33,000, and we shall have as a result that one pound of pure coal, burned in the perfect boiler in one minute, would, if we could apply it with absolute economy to the performance of work, exert a force of ($\frac{10980000}{33000} =$) 332 horse-power during one minute; or, if burned during an hour, then one sixtieth of 332, or 5·5 horse-power.

With a perfect boiler, therefore, we ought to get 5·5 horse-power per hour out of every pound of coal burned on the grate-bars. Now, let us inquire, What *do* we get in practice? Surely, you will say, our scientific mechanics and engineers have succeeded in getting a goodly percentage out of this possible figure; and the splendid engines, of massive construction, that work so beautifully as to excite our wonder and admiration at their smoothness and ease of their movements, must be very near perfection. Alas for the vanity of human expectations! Instead of getting 5·5 horse-power out of every pound of coal we burn in the boiler, the very best boiler and engine that have ever been constructed require two and a half pounds of coal to give out one horse-power: which means that, in spite of the vaunted progress of the mechanic arts in our times, the best engineering talent applied to the improvement of the steam-engine, from the time of James Watt down to Corliss, has only succeeded in making it yield a duty of 15 per cent. of what it ought to do, leaving an enormous margin of 85 per cent. for future improvements.

In the foregoing remarks I have, I fear, inadvertently been unjust to our engine-builders, for by far the greater portion of this 85 per cent. of wasted power is chargeable directly to the steam-boiler, and but a comparatively small proportion thereof to the engine. In considering the question of the duty of steam-motors, however, we must take the whole machine (engine and boiler), as a single apparatus. If our boiler-makers could do as well as our engine-builders—the two indus-

tries are quite separate, as you may know—the showing would be much more favorable.

It will be instructive, I think, to trace out the causes of the great waste of power that I have just pointed out, and to see if there are no means of remedying them. And if you will follow me, they will be very apparent.

The first and greatest source of loss resides in the difficulty—I may, I think, safely say the impossibility—of burning solid fuel economically in any form of furnace that has yet been devised ; and this prime difficulty is an unanswerable argument in favor of the substitution of liquid or gaseous fuel for steam-making as for other purposes. Let us analyze the matter : The buyer of coal purchases at the outset at least 10 to 15 per cent. of non-combustible and useless material with every pound of coal, in the form of ash ; while at least 5 per cent. more of the coal is lost by falling through the grate-bars in the form of the dust or partially burned fragments that find their way into the ash-pit unutilized. If even now, with so much waste as I have just indicated, we could really turn to useful account the whole of the thermal effect of the 85 per cent. or 80 per cent. of the combustible that we have left, we might well be content ; but such is far from being the case. The furnace gases can not, by any possible mode of constructing boilers, be retained long enough in contact with the steam-generator to yield up all their heat, and they are thrown out from the chimney frequently at a temperature of 800° Fahr. ; and, what is still worse, their combustion is frequently so imperfect that they carry off with them out of the chimney great volumes of unburned carbon in the form of smoke ; the cold air with which the fuel is fed, and which must become highly heated before it will begin to combine with the fuel, and which abstracts this heat from the glowing coals through which it passes, is another serious item of loss, which is intensified by the necessity of frequently opening the furnace-doors when large volumes of cold air rush into the fire-space ; and, lastly, the conduction and radiation of heat from the generator to surrounding objects complete the category of losses. Summing up all the items of loss in the steam-generator, it is probable that with the best forms of boilers which it has been possible to construct, not more than 25 per cent. of the theoretical thermal effect of the fuel is utilized in the generation of steam ; and of this 25 per cent., from 5 to 10 per cent. is lost somewhere on the passage of the steam from the boiler to and through the engine by condensation in steam-pipes, and friction of the machinery, leaving us but 15 or 20 per cent. actually realized in practice. I beg that you will not think that I have purposely made the case of the steam-engine worse than it is ; for, so far from doing so, I have actually made out the most favorable possible showing for it, by selecting for my example the best practice of the best makers.

Much of this loss, possibly the half of it, I have no hesitation in

ascribing to the use of solid fuel—coal or wood. And I take this opportunity of putting myself on record before you, as I have done for years persistently in the scientific journals, as an earnest advocate of fuel in the gaseous form, not only for industrial and manufacturing purposes, but also in the household. Let me give you a few thoughts on this subject.

The great and obvious advantage of gaseous fuel—to leave the question of its convenience, at present, out of sight—resides in the fact that the character of the fuel permits of its instantaneous and perfect intermixture with the air, by which a vastly more perfect combustion is insured—an advantage that finds admirable expression in the regenerative furnace of Siemens. Where Nature, however, supplies us with an abundance of combustible gases, as in certain favored localities in our oil regions, to which I shall have occasion to refer hereafter, an additional advantage is gained, since she has saved us the necessity of making it; and the practical utilization of the product of the numerous gas-wells of our oil regions has proved of enormous advantage to the manufacturers of these localities.

But in addition to the advantage I have just alluded to, namely, the great gain due to the more perfect combustion of gaseous fuel, there are other advantages on the score of convenience and economy that are no less important. I refer here to the saving in the carriage of coal from the yard to the place of delivery, and the recarriage of ashes—charges which are especially onerous in the numerous cases where boilers, stoves, etc., are located in the upper stories of buildings, or situated inconveniently as regards ordinary delivery by wagons. The saving in wages of stokers, to clear the fireplaces, and keep the heat of the furnace always at the proper intensity—difficulties which the adoption of gaseous fuel would entirely obviate, since it furnishes no ashes to remove—and the proper regulation of the gas supply, would insure a perfectly uniform heating effect for hours together, without supervision or attention of any kind. The incidental saving of fuel or steam, whenever, by improper regulation, or the inattention of stokers, the furnaces are allowed to become too hot; and, on the other hand, the saving in time and material that would otherwise be wasted by low fires and the frequent necessity of stoppages, until the required steam pressure is restored; and last, but not least, the great saving of fuel now universally wasted in keeping up boiler, and range, and heater, and stove fires overnight, and at all seasons—all these, and other items that I have probably overlooked in this hasty outline of the subject, form together an array of objectionable features sufficient to bring any system into disuse, where a remedy so easy to apply as the adoption of fuel in the gaseous state is at hand.

I do not wish to be understood as intimating that the use of our common burning-gas would be a panacea for all the ills I have narrated, for its cost would preclude its general adoption for industrial

purposes, to take the place of coal or wood. For domestic purposes, however, in the form of gas-stoves, even at the present high cost of this form of gas, it has been already largely adopted, and with advantage and economy; while for every form of light work, where power is only required intermittently, as in printing-offices, elevators, hoists, and the like, gas-engines, using ordinary coal-gas, are, even at present prices, decidedly more economical than steam, since they may be started and stopped instantaneously, and when idle are wasting nothing. And in the case of a steam-engine the steam must be kept up all the time, though the engine may not be wanted more than an hour or two in the day.

I look forward to the time, and I believe it is not far distant, when we shall have "heating-gas" laid through the streets of our cities and towns, side by side with lighting-gas and water-mains, and when our mills, and factories, and workshops, our parlors and kitchens, will be supplied with heat from that source, and when fires of wood and coal, with their abominations of dirt and ashes, and extravagance, will be looked upon as nuisances of the "good old times" when they knew no better.

To come back again to the subject of the steam-engine, from which I have digressed further than I had intended, I may mention the circumstance that the enormous wastefulness of this species of motor has originated the thought that electrical engines might be constructed to develop power more economically. A consideration of this topic, however, would take so much of our time this evening that I must pass it by with the brief remark that the galvanic battery can not compete in economy with the steam-engine, until some cheap mode of generating electricity shall be discovered. The fuel of the battery is zinc, and, even though we can get fifty per cent. of its theoretical power by burning it in the battery, its cost is so much higher than that of coal, the fuel of the steam-engine, that the latter has the advantage, at the present time, of forty to one on its side.

The recent great advances, however, that have been made in the construction and improvement of what are known as dynamo-electric machines, by which mechanical power, no matter how generated, whether from the steam-engine, the wind, or waterfall, could be directly converted into electricity, appear to have solved the problem of the cheap generation of electricity in any quantity, and have opened a wide field of speculation as to the possible extensive introduction of magnetic engines to take the place of steam. For I need scarcely tell you that electricity can be transmitted with but very little loss over great distances, by metallic conductors properly insulated, and made to drive magnetic engines to do the work of steam, or to furnish light for cities and towns, at pleasure. I shall take occasion to revert again to this very interesting topic in the course of the evening.

This remark brings us at length directly to the theme of my dis-

course—the "Waste Forces of Nature," to which I now invite your attention.

Of these, the first to be named, from the magnitude of the possibilities that advanced thinkers have attached to it, is that fountain of all terrestrial energy, our sun.

To introduce this topic properly, I beg to remind you at the outset that the progress of science during the last half century has been most pronounced and satisfactory in the investigation of the nature, origin, interdependence, and interconvertibility of the various manifestations of energy that are called familiarly "the forces of nature"; and among the most philosophical generalizations that the science of our times may boast of having established is the demonstration, upon the most complete and satisfactory experimental evidence, that every manifestation of terrestrial activity has more or less directly a solar origin. Every exhibition of force, physical or chemical, inorganic or vital, the multifarious consequences connected with the circulation of air and water over the surface of the earth, and in her oceans, and which involve the causation of the winds, aërial and aqueous currents, and rainfall, and the effects of these commonplace but vastly important phenomena in establishing and maintaining those climatic conditions upon which the existence of life upon the earth is absolutely dependent, are directly referable to the forces of solar radiation. Ay, there is good reason for the belief, which is entertained by most competent and eminent authorities, that the periodical recurrence of famines and pestilences and other scourges that afflict mankind, and which the superstitions of all ages are wont to ascribe to the anger of an offended deity, coincides with the periodical maxima and minima in the intensity of the solar emanations that reach the earth; and that even such apparently disconnected and arbitrary things as the social and political affairs of mankind, which are intimately bound up with the successful pursuit of agriculture and commerce, are therefore demonstrably under the direct and immediate dominion of the solar rays.

But, to return from a digression that is only of incidental interest to us here, I desire you to conceive of the amazing fact that the stupendous aggregate of terrestrial activity is derived from that infinitesimal fraction only of the solar emanations that is intercepted by the earth—a fraction less than the two-billionth part of the sum total of energy that he is unceasingly radiating into space; and it is my immediate purpose here to invite your attention to the interesting question whether it is within human reach to convert a portion of the measureless floods of power that the sun pours out upon the earth into mechanical energy, or into other forms in which it will be more directly available for useful purposes.

The proposition here announced, I must advise you, is not the visionary notion of impracticable theorists, but is one that, on the con-

trary, has seriously occupied the attention of such eminent practical engineers and mechanics as Ericsson, and others scarcely less widely and favorably known; and, although up to the present time nothing very tangible has resulted from their labors, they have at least succeeded in demonstrating, beyond reasonable doubt, that the problem is susceptible of practical solution.

To convey some adequate notion of the incalculable floods of power that await the bidding of the compelling genius of invention, I will invite your attention to a very brief *résumé* of the well-substantiated results of scientific research applied to the subject. The French physicist Pouillet, with the aid of elaborately refined apparatus, estimated that the earth receives from the sun in each and every minute 2,247 billions of units of heat—a quantity sufficient, if converted into mechanical force, to raise 2,247 billions × 774 pounds to the height of one foot. To come down to figures that are less difficult of conception, let us confine our attention to that part of the solar heat that falls upon the oceans, and to the fraction of that portion which is expended in the work of evaporating the water.

Without entering into an explanation of the modes in which the following calculations have been made, and which would run into far greater length than the limited time at my disposal this evening would warrant, I will simply give you the results.

I have said, you will remember, that we would confine our attention to that portion of the solar heat that falls upon the oceans, and to that fraction of it which is expended in the work of evaporating the water; in doing which alone, the sun raises during every minute an average of not less than 2,000,000,000 tons of water to a height of 3½ miles—the mean altitude of the clouds. To express this prodigious exercise of power in more familiar form, I may put it this way, that to continuously raise this weight of water to the height of 3½ miles per minute would require the continuous exercise of the force of 2,757,000,000,000 horses per minute.

Here, then, is power enough to satisfy the most enthusiastic inventor, and leave him plenty of margin; and if the believers in the sun-engine shall ever succeed in giving mechanical expression to but the merest fraction of this superabundance, they may safely count upon creating as profound a revolution in the world of industry as that which was ushered in with the steam-engine.

Ericsson, who has devoted much study to this enticing problem, has announced his unqualified belief that the sun-engine is practicable. He has progressed so far as to lay down the general principles on which he proposes to construct such a motor, and which he has actually put into practice in the production of an engine that runs with great uniformity at a speed of 240 revolutions per minute, and consuming at this rate only part of the steam made by the solar generator employed. From the very brief and imperfect accounts that have

been made public, it appears that the Ericsson sun-engine is composed of three distinct parts—the engine proper, that is, the working mechanism, the steam-generator, and the concentrating apparatus, by means of which last the feeble intensity of the sun's rays is augmented to the degree that will suffice to produce steam at a practical working pressure.

He claims that this concentrating apparatus will abstract on the average, for all latitudes between 45° north and 45° south, fully 3½ heat-units for every square foot presented vertically to the sun's rays. With 100 square feet of surface in his concentrating apparatus, therefore, he believes it will be possible to continuously develop from the sun's rays 8·2 horse-power during nine hours within the above-named range of latitude.

Mouchot, who, so far as the practical construction of the solar engine is concerned, has progressed further even than Ericsson, exhibited at the late Exposition at Paris a working sun-engine upon substantially the same general principle of construction as that above described, and which, from its novelty and the importance of the principle it illustrated, received universal popular attention and a most encouraging and flattering report of the judges of awards.

Not to over-estimate the capabilities of the new system, Ericsson, in his consideration of the practical side of the subject, assumes that a sun-engine of one horse-power will demand the concentration of heat from one hundred square feet; and on this estimate he proceeds to show that in all reasonable probability those regions of the earth that now suffer from an excess of heat will some day derive such benefits from their unlimited command of motive power as to vastly overbalance their climatic disadvantages. He proposes the sun-engine only for those regions where there is steady sunshine, and has mapped out extensive tracts of land aggregating no less than 9,000 miles in length and 1,000 miles in breadth, including therein the southern coast of the Mediterranean, Upper Egypt, much of the Red Sea region, the greater part of Persia and Arabia, and portions of China, Thibet, and Mongolia, in the Eastern Hemisphere; and Lower California, the Mexican plateau, Guatemala, and the west coast of South America for a distance of 2,000 miles, as the field of the solar empire of the future. As an evidence of the sincerity of his belief in the realization of these ideas, let me quote you the following enthusiastic passage from one of his numerous essays upon this subject: "The time will come," asserts Ericsson, "when Europe must stop her mills and factories for want of coal. Upper Egypt then, with her never-ceasing sun-power, will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the sides of the alluvial plain of the Nile, where sufficient power can be obtained to enable him to run more spindles than a hundred Manchesters."

For centuries past the wind has been put to work with very good

results, and in some countries, notably in Holland, quite extensively. From the best advices I have upon this topic I have it that there are in that country no less than 12,000 windmills, averaging eight horse-power each, giving a total of 96,000 horse-power.

The chief and obvious difficulties that intrude themselves against the extensive use of the wind as a motive power for general industrial uses are that in most locations it is intermittent in its action, extremely variable as to its power, and quite unreliable as to the time and duration of its manifestations.

The immense power stored up in this unfortunately unreliable agent will appear from the statement that a wind of three miles per hour travels 4·40 feet per second, and exerts a pressure of 0·32 to 0·44 pound per square foot of surface opposed to its action. A wind of twenty-five miles an hour, or what sailors would call a good stiff breeze, travels 39·67 feet per second, and exerts a pressure of from 2·208 to 3·075 pounds per square foot. The prodigious energy of a hurricane, traveling not infrequently at the rate of one hundred miles per hour, is too well known by its disastrous effects to need repetition. The power of the wind, however, save for ship-propulsion, is utilized in but few situations, its unreliability having caused it to be but very slightly esteemed in comparison with water-power and steam. Of late, however, small windmills, especially designed with superior mechanical skill, have been rapidly growing in popularity in this country, mainly for pumping water for railway and domestic purposes, an application for which these devices are excellently adapted; and I entertain no doubt that there are many situations where work is to be done that does not demand a continuous exercise of power, and where the prime consideration to be observed is the element of cheapness, where wind-power might be most advantageously employed. There are, again, extensive regions of the earth, extending for ten or more degrees north and south of the equator, where the winds blow continuously from one direction throughout the greater portion of the year—I need hardly remind you that I refer to the region of the "trade-winds," and in which, especially along the coast-line where their influence is not disturbed by mountain ranges and other conflicting causes, the force of the wind may be relied upon with almost absolute certainty for the whole or the greater portion of the year. In such regions, therefore, Nature has supplied us with an exhaustless store of energy, capable of meeting the most extravagant demands that may be made upon it. Even the region of the temperate zones, where the winds are variable, our seashores have their strong land- and sea-breezes which for nine days out of ten may be relied upon; and even in situations where wind-power is most unreliable, as in the interior of the continents, there is a vast and valuable field open for some practical and generally applicable system by which the power of the wind, at present almost universally allowed to go to waste, may be stored up to be given out again as it

may be required for service; for it may be made to coil a spring, to raise heavy weights, or lift water into elevated reservoirs, or, by other simple devices well known to the mechanical engineer, to store up its power, which may be subsequently given out through machines especially adapted for the purpose.

The tides ebbing and flowing twice daily, lifting upon their bosom, like so many corks, the heaviest vessels, and baffling all efforts to restrain their resistless force, afford us another instructive topic for consideration in treating of the wasted forces of Nature—for here, again, she has lavished out of her superabundance infinitely more power than any conceivable increase of the needs and industries of man could ever employ.

The rise and fall of the tides vary, according to local conditions, from a few inches, as in the Mediterranean Sea, to seventy feet, as in the Bay of Fundy, and their force in almost any one of our rivers would, if properly applied, suffice to furnish ample power to all the mills and factories and workshops that could be built side by side upon their banks. They would drive under-shot wheels unfailingly. Where there are extensive meadows regularly overflowed, as they commonly exist along all of our larger streams, a levee containing two sluices, each supplied with a turbine water-wheel, one to be driven by the ebb and the other by the flow, could be made to utilize incalculable power.

In some exceptionally favorable localities, where the conditions have forced themselves upon the attention of observing and practical men, tide-motors have been introduced, and with great advantage; but the general utilization of these exhaustless and continuous stores of energy still remains to be accomplished.

Great rivers above tide-water are rolling down a wealth of power in their currents; and a hundred factories along their banks, heedless of the fact, are using steam-power. And it is one of the standing marvels that manufacturers fail to recognize the elementary fact in mechanics, that it is not necessary for a stream to have from ten to two hundred feet of fall, in order to do their work; while the great rivers upon whose banks their workshops are perched are permitted heedlessly to pour out trillions of cubic feet of water, year after year, into the ocean, opposing no mechanical difficulties in the way of yielding up their inexhaustible supplies of power.

Who may estimate the wealth of power poured out in unheeded profusion by our great waterfalls from Niagara down? Confining our attention to the one grand cataract, try to conceive of two million tons of water per minute hurled down that ledge of rock, representing 56,000 horse-power expended every minute in the work of disintegrating and undermining the rocky river-bed below. A few tiny paddles, I am told, dip into the current above the falls, and drive a paper-mill, but what of the millions of horse-power that are allowed

to run heedlessly to waste down that great fall of 157 feet, in a sheet twenty feet thick and 4,750 feet broad?

The gas-wells of the oil regions have been permitted to spout away wealth enough to have repaid a hundred-fold all the money ever lost in oil speculations; but it is gratifying to be able to say that the great value of these natural supplies of heat and light is now very generally recognized, and that in many localities the gas is turned to useful account in supplying light and heat to towns and cities and factories and mills.

In some of the cases that I have called to your attention, the power is steady and unremitting, in others it is too violent or too uncertain for direct application. In the first instance, uses for the power may be found at once; in the last, means for storing it up must be provided, and would, beyond question, abundantly repay the undertaking. For this purpose, the raising of weights or of water into elevated reservoirs, and the compressing of air, afford two simple and ready means of storing up power to be let loose as required; while other means of a mechanical nature to accomplish the same purpose will readily occur to my mechanical hearers.

While upon this point, I must not omit to state one fact of the greatest interest that is now attracting the attention of some of the highest living authorities. I refer to the question of the practicability of transmitting mechanical power to great distances by converting it into electricity, through the agency of what are called dynamo-electric machines, and utilizing this either for the production of powerful lights for illuminating cities and towns, or by converting it back again into mechanical power with the aid of magneto-electric engines, by which mills, factories, and workshops may be furnished with the power they now obtain from steam or water. It will be very *à propos*, in this connection, to notice that the feasibility of transmitting to great distances the almost incredible power of Niagara Falls, by some such means as that above named, has been affirmed by many scientific investigators of eminence.

Dr. C. W. Siemens, in his presidential address before the last meeting of the Iron and Steel Institute, in touching upon the highly interesting subject of the employment of electricity as a substitute for steam, made the following instructive statements: He declared that so long as the source of electrical power depended upon the galvanic battery, it must, in the present state of things, remain far more expensive than steam-power, for the obvious reason that zinc, which is the fuel of the galvanic battery, is vastly more expensive than coal, the fuel of the steam-boiler. If, however, continues Dr. Siemens, a natural force, such as water-power, mark you, could be utilized to generate electricity economically, the case would be very different. A dynamo-electric machine actuated by water-power could be made to generate powerful electrical currents, which could be transmitted through insu-

lated metallic wires or cables to a great distance with but little loss, comparatively speaking, and could thus be made to run magneto-electric engines to do the work of steam in our mills and workshops, to ignite electric lamps, etc. A copper rod, or cable, three inches in diameter, says Dr. Siemens, would be capable of transmitting a thousand horse-power to a distance of say thirty miles—an amount sufficient to give the light of a quarter million of candles, and suffice to illuminate a town of moderate size. Two eminent American investigators, Professors Houston and Thomson, of Philadelphia, having just made an investigation with the especial purpose of determining the practicability of transmitting the power of Niagara to great distances by means of electricity, go even further than Dr. Siemens. They make the astonishing assertion—and, what is more, they prove it—that it would be possible, should it prove to be desirable, to convey the whole power of Niagara to the distance of 500 miles or more by means of a copper cable not exceeding a half inch in thickness.

It is unnecessary for me to multiply examples upon this fruitful theme of speculation, for the time admonishes me that I have already trespassed sufficiently upon your attention, and I think I have convinced you very fully that such queries as What shall we do when our coal-fields are exhausted? need cause us no anxiety, for centuries before this possibility shall be realized, I opine, the world will no longer stand in need of them.

THE GEOLOGICAL SURVEY OF THE FORTIETH PARALLEL.

By Professor J. S. NEWBERRY.

THE geological survey of the country bordering the fortieth parallel of latitude was made under the direction of the War Department by a party under Mr. Clarence King, who took the field in 1867. The area covered by the survey was a belt one hundred miles wide, traversed by the Pacific Railroad between the Great Plains on the east and the Sierra Nevada on the west, approximately between the 104th and 120th meridians of longitude. The general object of the survey was to connect the region of which the geological structure has been made known through the California survey on the west with the explored portion of the Mississippi Valley, and thus to supply the material for completing a section across the continent. In addition to this it was proposed to determine by careful investigation the structure and resources of the country lying adjacent to the Pacific Railroad, which by the construction of this great work was opened to occupation, and was already invaded by a population eager to seize and develop its hidden stores of mineral wealth.

Mr. King chose as his geological assistants the brothers J. D. and Arnold Hague, and S. F. Emmons, all of whom had received good training in the geological survey of California, and proved competent and congenial co-laborers with him. Specialists were also engaged to study the materials collected in other departments of natural science; the fossils being placed in the hands of Mr. F. B. Meek, and, after his death, in those of Professor James Hall and Mr. R. P. Whitfield. The botanist of the survey was Mr. Sereno Watson, and the ornithologist Mr. Robert Ridgway, while a special investigation of the volcanic rocks collected was made by Professor Ferdinand Zirkel, the distinguished lithologist of Leipsic. The topographical work of the survey was, during the greater part of its continuance, in charge of Mr. J. T. Gardner, now director of the Topographical Survey of the State of New York.

The report of the "Survey of the Fortieth Parallel," as now published, consists of six volumes quarto. Of these the first issued (1870) was Vol. III. of the series, entitled "Mining Industry," and devoted to a description and discussion of the important mines and mining districts embraced in the territory studied. About half of the volume is taken up with a detailed description of the Comstock lode—the most productive deposit of gold and silver yet discovered—and of the methods of exploitation followed in the different mines located upon it, by Mr. King and J. D. Hague. It also contains chapters by Mr. Arnold Hague on the "Chemistry of the Washoe Silver Process," and on the "Geology of the White Pine Mining District"; the "Geology of the Toyabe Range," by S. F. Emmons; and on the "Geological Distribution of Mining Districts," and the "Green River Coal Basin," by Mr. King. This volume is accompanied by an atlas of maps, plans, and sections, which at the time of its appearance was by far the most beautiful work of its kind published in this country.

It is greatly to be regretted that the review of the mining industry of the country bordering the Pacific Railroad, so admirably begun in this volume, could not have been continued through the life of the survey, and have been presented to the public at its close. Since the publication of this discussion of the Comstock lode, the most important chapters in its history have been enacted, and it is a pity they should not also have been written. When Mr. King closed his examination the workings had reached a depth of a little more than 1,000 feet, and the maximum temperature (of water at bottom) was about 108° Fahr.; and now the depth of 2,500 feet has been reached, the temperature of the water at the bottom is 160°, and facts have been obtained which indicate that the limits of the successful working of the lode will be determined by temperature and these limits soon be reached.

The Sutro Tunnel has also been constructed and all its geological revelations made since the appearance of Vol. III. The great bubbles of the White Pine and the Emma mines have since swollen and burst,

and the important litigation between the Eureka and Richmond has been decided on geological grounds; and yet the public has nowhere received the information which it craves as to how it has happened that so many millions have been made from the Comstock mines (by their managers), and so many lost in the White Pine and Emma. The great bonanzas of the California and Consolidated Virginia have nowhere been fully described. A few geologists know that they are simply disconnected patches of rich ore, such as lie in most fissure veins; but the public at large have either no ideas at all about them, or those that are wide of the truth. So we may search in vain through all mining literature for the simple explanation of the problem involved in the Eureka litigation, and in the ephemeral productiveness of the White Pine and Emma, viz., that these mineral deposits are chambers or galleries formed in limestone *beds* by atmospheric water carrying carbonic acid, and subsequently occupied with ore deposited from ascending solutions which filled these cavities, just as elsewhere the simple crevices of fissure veins.

If any one can imagine the lead-bearing limestones of Missouri or the honeycombed plateau of central Kentucky broken up by volcanic action, the strata set at high angles, and their irregular cavities filled with mineral solutions issuing through fissures from below, he will get a just view of the nature and origin of these mysterious ore deposits, and a ready explanation of their irregular and superficial character.

If Mr. King could have continued his observations on the Comstock, and had investigated all the mineral deposits discovered along this rich belt, so freely opened by the active exploitation of the last ten years, in the same thorough way that he did the Comstock, he would have made a contribution to American geological literature which would have been of great scientific interest, and of a pecuniary value to mine-owners and mine-buyers to be reckoned in millions.

Vol. V. made its appearance in 1871; it was devoted to Botany, and was prepared by Mr. Sereno Watson, with the assistance of a number of our best botanists, who have made special studies of particular families of plants; as Engelmann of the *Cactaceæ*, Eaton of the Ferns, Tuckerman of the Lichens, etc. Vol. VI., on Microscopic Petrography, by Professor Ferdinand Zirkel, was published in 1876; Vol. IV., on Paleontology and Ornithology, in 1877; Vol. II., which embraces detailed reports by Messrs. Arnold Hague and S. F. Emmons, on the local geology of the belt of territory surveyed, also appeared in the same year; and, finally, Vol. I., written by Mr. King himself, forming a comprehensive review of the systematic geology of the country covered by his explorations, has only just now left the binder's hands.

The magnificent geological atlas intended to accompany and illustrate the reports of the "Survey of the Fortieth Parallel" was issued in 1876. This will compare favorably with any work of its kind done in the Old World, and at the time of its publication it far excelled

anything which had before been attempted in this country. To the good taste and the technical skill of Mr. Julius Bien, of New York, Mr. King is largely indebted for the beauty and accuracy of this atlas; and it may be a matter of general congratulation among American geologists that it was then demonstrated that the cartographic art had been carried to as great perfection here as anywhere else in the world, and that all known refinements of graphic illustration are within their reach.

All the volumes of the "Report of the Fortieth Parallel Survey," except Vol. I., have been more or less thoroughly reviewed in the scientific journals, and it is therefore unnecessary that they should receive further notice here. It is but just, however, to say of the general character of the report of Mr. King, now for the first time collectively exhibited, that it takes high rank in the literature of the subjects which it considers, and is most creditable to the chief under whose direction the work here recorded was executed, and to his assistants, both for the great amount and excellent quality of that work, and from the good taste and care which the volumes and maps display.

Perhaps no other geologist has enjoyed the opportunity of directing the exploration of so wide and interesting a field, has been so independent and untrammeled in his action, and has had such resources at his command as Mr. King; and something of his success should be ascribed to his good fortune. Yet it is true that he has made excellent use of his exceptional opportunities, and the result can not in justice but be regarded as alike honorable to him, to the War Department under whose auspices the survey was made, and to the country.

In the volume just issued Mr. King has discussed the exposures of all the different systems of rocks which form the geological column, beginning with the Archæan and ending with the Quaternary. He then takes up the volcanic rocks, of which there is such an immense display in the western part of his field, and discusses their relations, succession, and classification. His last chapter is devoted to orography, and is a study of the different and very numerous mountain chains and axes of elevation which occupy so much of the region he has studied. In the progress of this review he has not only made great and important additions to what was before known of the distribution and development of the different geological formations throughout the West, but has subjected each group of rocks and each important topographical feature to close and careful study, with the view of evolving from its ascertained structure the details of its history. In these investigations he has touched upon some of the most profound problems that have engaged the attention of geologists and physicists; and while we can not assert, and he will hardly claim, that all the conclusions he has reached will be confirmed by further observation and mathematical analysis—for all human work is imperfect—yet it can not be denied that the facts he has reported and the inductions he has

proposed will have an important influence on the progress of geology, especially in this country.

The publication of Mr. King's volume certainly throws a flood of light on the complicated and hitherto somewhat chaotic geology of our Western Territories, and it can not fail to afford important aid in the proper orientation of both observers and observations in all the great region west of the Mississippi.

It is evident that nothing like a thorough discussion of the facts and conclusions contained in Mr. King's great volume of eight hundred quarto pages can be given here; but some of the most important of his facts, and the more interesting of his generalizations, will be briefly noticed in the succeeding pages.

Archæan.—By this term, which he accepts from Dana, Mr. King designates all the great mass of crystalline schists and granitoid rocks which underlie the Cambrian system, and form the base of his grand section. These are most fully exposed in the Park and Medicine Bow Ranges of Colorado and Wyoming, and in the Humboldt and Truckee Mountains of Nevada; but there are also numerous minor ranges and summits composed of granitoid rocks, especially west of Salt Lake; and Mr. King shows that these latter exposures are portions of a broad pre-Cambrian land-surface which formed the western border of a great topographical basin that reached to the Rocky Mountains on the east. This basin was occupied by the seas from which were deposited the Palæozoic rocks. These latter were largely derived from the erosion of the neighboring land on the west, and formed a conformable series, of which the estimated thickness is over 30,000 feet. The old land which supplied the mechanical material of the Palæozoic strata extended to an unknown distance northward, and reached southward at least to the present head of the Gulf of California, in a region where it was recognized by the writer, and its relations to the Palæozoic series of the Colorado plateau pointed out in the "Report of the Colorado Exploration," 1861.

Mr. King divides the Archæan rocks into two great groups, of which the first consists at base of gray or flesh-colored bedded granite, overlain by red, massive granite, on which lie red, micaceous, bedded granites, the whole attaining a thickness of perhaps 25,000 feet. This group is characterized by the presence of quartz, orthoclase, and oligoclase feldspars, with a little hornblende and mica, the latter consisting of biotite, muscovite, and lepidomelane. It also contains more or less labradorite, titaniferous iron, magnetite, and graphite, the whole corresponding closely with the Laurentian of Canada.

The upper subdivision of Archæan rocks—found in the Medicine Bow and Park Ranges, the Uintah, Wahsatch, Humboldt Mountains, etc.—consists of true gneisses, interstratified with mica schists, often garnetiferous, hornblende schist, sometimes with zircon, etc., all very distinctly, often minutely stratified. The thickness of this group is in

the Wahsatch and Humboldt Mountains, from 12,000 to 14,000 feet, in the Park and Medicine Bow Ranges somewhat less, and in the Clear Creek region of Colorado at least 25,000 feet. This upper group will be recognized by geologists as closely resembling the Huronian rocks of the East. The Archæan nucleus of the Black Hills was reported by the late Mr. Henry Newton to be composed of two groups of crystalline rocks closely resembling those described by Mr. King, and Mr. George M. Dawson found a similar double series in Manitoba and British Columbia. Without absolute proof—which it would be difficult if not impossible to obtain—the inference is at least allowable that the rocks underlying the Palæozoic series in the far West correspond to the Laurentian and Huronian Groups of the Canadian geologists, and therefore that the foundation of the western half of the continent is essentially the same with that of the eastern; and also that there, as here, a broad continental surface of these older rocks supplied by erosion the mechanical material that entered into the composition of the Palæozoic sediments, which, by successive oscillations of sea-level, were spread to varying altitudes upon its flanks.

At the close of his chapter on the Archæan, Mr. King proposes a theory of the genesis of granite and crystalline schists, which is in some respects new. In common with most of the geologists of the present day, he supposes that the granites and schists are sedimentary rocks which, having locally accumulated to great thickness, have sunk by their own weight into the yielding crust of the earth to a point where they have suffered more or less aqueo-igneous softening, and then, in his view, under varying intensities of radial and tangential pressure, they have been converted into corrugated schists or massive granite, according to the less or greater energy of the forces acting upon them. The evidence adduced by Mr. King to support this mechanical theory of the origin of granite is chiefly derived from the facts which indicate internal and bodily movement in granite, such as the dislocation of inclosed minerals, and the inclusion of masses of foreign rocks.

That there has sometimes been more movement in granites than in the schists with which they are associated—and of which they can frequently be shown to be the exact equivalents in a more metamorphosed condition—is quite certain; but it is very difficult to separate here the effects of force from those of heat. Either produces the practical plasticity which we see recorded in the obliteration of bedding, and the inclusion of foreign rocks. Granites, which exhibit the extreme phase of metamorphism, have evidently been in a plastic state, for they have been forced into fissures of other rocks to form veins and extruded mountain-crests—proofs of softening and movement which schists never afford—but whether this plasticity was the effect of greater heat or greater force than the associated schists suffered, is a question not answered by any facts yet cited. The dislocation of included min-

erals indicates force; the inclosure of blocks of foreign material, when these blocks are masses of metamorphic schists, indicates plasticity, but affords no test of temperature. Where the included blocks are limestone, as in the granite of the Pyrenees described by Green ("Physical Geology," p. 322), and these blocks are externally metamorphosed, internally unchanged, we have a record of softening and heat, but not the heat of fusion. The coarser crystallization of granite means that it has been more or longer softened, so that its component minerals were free to crystallize out; but no distortion or dislocation of these minerals affords stronger proof of internal movement than is furnished by the associated schists, in which the fossils often not wholly obliterated are quite as much distorted as any minerals in the granite. The inclusion in granite of blocks of slate which have been transported some distance from their place of origin, supplies, however, conclusive evidence of movement which may even be called a flow. Cases of this kind, which are of great interest and significance, were observed by Mr. Newton in the Black Hills. The granite core of this mountain-chain incloses large angular blocks of metamorphic slate which have been torn from their connections and carried bodily upward. The granite also shows a kind of slickenside-jointing, which proves that when in a plastic but not fused condition it was squeezed out of a fissure or opening in the harder overlying schists. We have here proof that the granite in its lower position has been more *softened* than the schists, and that it has been more moved; but we have no proof that it has been subjected to greater pressure.

In contrast with the theory of Mr. King, that granites have been produced by great pressure, is that promulgated by Mr. H. F. Walling (Proceedings of the American Association at the St. Louis meeting), in which lateral pressure is practically ignored as a cause of metamorphism. Mr. Walling, supposing, with others, that sediments accumulating along shores have sunk by their gravity, recognizing the fact that the static equilibrium must be maintained by the rising of the areas lightened by erosion in the removal of these sediments, attributes mountain elevation to this ascent, and the corrugation of metamorphosed rocks to the lateral flow of material from the sinking to the rising areas. There is certainly great force in the reasoning used by Mr. Walling to show that there must be rising as well as sinking areas, and a subterranean flow of matter from one to the other to compensate for the transfer of eroded material on the surface; but it seems doubtful whether the traction produced by the adhesion of the solid strata above to the moving mass below could produce slaty cleavage and other phenomena, which we have been accustomed to attribute to the lateral thrust produced by the crushing down of the rigid crust on a shrinking nucleus. It is hardly necessary to say that the metamorphism of granite is, according to Mr. Walling, due to the subterranean heat to which it has been exposed in its descent far below the surface.

Probably the final conclusion reached in the discussion of the origin of granites, to which Mr. King has certainly contributed many new and interesting facts, will be that each of the causes, heat and pressure, should be credited with a share of the effects produced.

Palæozoic.—One of the most interesting and surprising results of Mr. King's exploration is the discovery of a section of stratified and unmetamorphosed strata said to be conformable throughout, reaching from the base of the Cambrian to the top of the Carboniferous, and attaining a maximum thickness of 32,000 feet. No section of the Palæozoic rocks of equal magnitude has yet been discovered elsewhere in the world, and the announcement will doubtless be received with some incredulity by geologists, but the accuracy with which the measurements were taken by Mr. King and his assistants, and the vindication of his classification afforded by the fossils, which were carefully reviewed by Mr. Meek, Professor Hall, and Mr. Whitfield, seem to leave no room for doubt. This great group of rocks is said, as before stated, to have been laid down in a basin bounded on the east by the ranges of the Rocky Mountains in Colorado, and on the west by a broad archæan area in Nevada. In the middle rose the lofty islands of the Wahsatch, which toward the west presented an abrupt slope of 30,000 feet, against which the Palæozoic rocks abutted. From the inclosed character of this sea most of the sediments formed in it are mechanical, and represent the wash from the adjacent land, but in the middle of the section occurs what Mr. King calls the *Wahsatch limestone* (Lower Carboniferous and Upper Devonian), seven thousand feet in thickness. Although no certain measure of time is afforded by the mechanical sediments—since the rapidity with which they were deposited may have varied indefinitely with the activity of eroding agents—this great limestone mass, formed as it must have been through organic agencies, represents a lapse of time which is almost beyond the reach of the imagination; and if, as Mr. King states, the Palæozoic series is essentially conformable throughout the area it occupies, we have here evidence of a stability in the physical conditions of this portion of the earth's surface, which, so far as known, is without parallel.

Mr. King gives two sections of the Palæozoic series taken, one in the Wahsatch Mountains and the other in Middle Nevada, which differ only in minor details. The Wahsatch section is, however, the most complete, as it shows the base of the Cambrian system, which is not visible farther west; it is as follows:

1. Permian	615	feet.
2. Upper Coal Measure limestone	2,000	"
3. Weber quartzite, Carboniferous, and Devonian	6,000	"
4. Wahsatch limestone, Carboniferous, and Devonian	7,000	"
5. Ogden quartzite, Devonian	1,000	"
6. Ute limestone, Silurian	1,000	"
7. Cambrian silecious schists	11,000	"
8. Cambrian slates	800	"

Mesozoic.—At the close of the Palæozoic ages great changes took place in the topography of the central and western portions of the continent, all of which are for the first time made clearly known by Mr. King's graphic and lucid descriptions in his chapters on the "Mesozoic Areas of the Fortieth Parallel." After the deposition of the great and conformable series of Palæozoic rocks in the central basin, the Archæan continent, which formed the western limit of these older deposits, and which had continued dry land to the close of the Carboniferous age, was sunk under the waves of the Pacific, and thus remained during the Triassic and Jurassic ages—long enough for the deposition of about 20,000 feet of sediments, of which considerably more than half belong to the Trias. Then the great fold of the Sierra Nevada was raised high above the ocean-level, carrying with it all the table-land of the Great Basin, which has not since been covered with salt-water. The rocks composing the Sierra Nevada are chiefly the Jurassic and Triassic beds, here often completely metamorphosed and converted into crystalline slates and massive granites, in which lie the auriferous veins that have supplied the $1,000,000,000 of gold already taken from the California placers and quartz mines. This paroxysm, or rather period of elevation, occurred before the Cretaceous age; for, in all the interval between the Wahsatch and the Sierra Nevada, no Cretaceous rocks are found. On the Pacific side of the great Sierra, however, Cretaceous strata lie nearly horizontal, abutting against the upturned Jurassic and Triassic slates, and reaching to a height of some 1,200 feet above the present ocean-level.

East of the Wahsatch a very different history is recorded, for here the Triassic, Jurassic, and Cretaceous strata were deposited not only in a series conformable among themselves, but apparently with the Palæozoic rocks below. This conformability is, however, more apparent than real, for the region between the Wahsatch and the Mississippi gives abundant evidence of elevation and subsidence during the Mesozoic ages; but these changes of level were continental rather than local, and over an area of hundreds of thousands of square miles the surface on which the strata were deposited was so nearly level that no want of parallelism in their planes of deposition is visible to the eye. That great changes of level did take place in this region is evident from the facts, first, that on the area over which the Triassic beds were deposited, extending from the Colorado to the Mississippi, mechanical and shallow water deposits alone prevail. No limestones occur here in the Trias, but it is made up of great sheets of cross-stratified and tide-swept sand of brilliant colors, chiefly bright red—due to the complete oxidation of their iron from aëration, and the absence of organic matter—with here and there heavy beds of gypsum, and formerly of salt; all the records of the intermittent action of a shallow sea. This sea-bottom over the interval between the Rocky Mountains and the Mississippi became dry land at the close of the Trias; for the Jurassic

strata which occupy much of Colorado, Utah, and Nevada, scarcely reach eastward beyond the mountains; and the Cretaceous age was marked by a great submergence which carried the shore-line progressively from the Gulf of Mexico to the Wahsatch, and northward, perhaps, to the Arctic Sea, converting all the area between the Wahsatch Mountains and the Canadian highlands into a sea, in which were deposited in some places 2,000 feet of limestone, the slow accumulation of calcareous matter from the growth and decay of marine organisms.

From Mr. King's careful study of the Mesozoic rocks of Nevada, we learn that the Trias consists of alternations of limestone and quartzite, which, in Star Peak, form a continuous section of over 10,000 feet. The fossils which the limestones contain show that much the larger part of this mass belongs to the Alpen Trias of the Old World, the Halstadt and Saint Cassian beds, and those which form the passage to the Jura.

The Jurassic rocks of Nevada are mostly shales—the deposits from water too shallow for limestones—and contain few fossils. Along the eastern margin of the Jurassic area in the Black Hills, the Jurassic beds are more purely marine, and are far richer in fossils. The upper portion of these beds, which are of an estuarine or littoral character, has lately been discovered to be a vast cemetery of vertebrate animals, some of which are of unequaled size, and in their structure of special interest. Among these are the huge dinosaurs described by Marsh and Cope, some of which far exceed in dimensions any terrestrial animals before known, the largest, according to Marsh, having a length of at least one hundred feet, and a height of twenty-five or thirty.

The uppermost member of Mr. King's Mesozoic section is the somewhat famous *Laramie group*—the Lignitic formation of Dana, so named because it contains the most important coal-beds of Colorado. The age of this group of rocks has been much discussed by Dr. Hayden and Lesquereux, the distinguished fossil botanist, and it has been represented by them to be Tertiary, on the evidence of its numerous fossil plants; Cope, however, found the remains of Cretaceous vertebrates, and Meek, Cretaceous mollusks, in it; and hence it was said to have a Cretaceous fauna and a Tertiary flora. The writer has, however, for a long time contended that its flora was distinct from that of the Tertiary rocks, and the proof was stronger that it was Cretaceous. Mr. King adduces new and apparently conclusive evidence that it is older than the Tertiary, since, like Cope, Meek, and Stevenson, he has obtained numerous Cretaceous animal remains from it, and finds it to underlie unconformably the Coryphodon beds, the oldest portion of the Eocene.

TERTIARY.—The pictures which geology presents to us of the far West during the Tertiary age are totally different from those which preceded them, and, on the whole, more varied and interesting. As

we learn from various sources, at the close of the Cretaceous the wide-spread sea of that age was withdrawn from the interior of the continent, and all the interval between the Sierra Nevada and the Canadian highlands became a land-surface, while in the lower valley of the Mississippi, and on the Gulf and Atlantic coasts of the eastern half of the continent, the sea stood higher than before or now, for marine Tertiary strata form a broad marginal belt reaching around the old land from New York to and up into the Mississippi Valley. In the region of the Plains, the Rocky Mountains, and the Great Basin, however, we find no marine Tertiaries, but abundant evidence that, instead of the former sea-surface, a broad continental area stretched from the Arctic Ocean southward through and beyond the Territories of the United States. This continent was marked by few bold topographical features, since the Rocky Mountain system was then slowly growing, and had attained nothing like its present magnitude. The surface was, however, varied with low mountain-chains, broad savannas, strongly flowing rivers, and a series of fresh-water lakes, which in magnitude far exceeded any now on the earth's surface. The climate was mild and genial even to the North Sea, and the land was clothed with a vegetation more luxuriant and varied than that which it now bears. Of the magnitude of its forest growth we have evidence not only in the abundant remains of trunk and leaf and fruit imbedded in the old lake sediments, but in the scattered remnants of its former grandeur seen in the gigantic conifers of California, and in the cypress, magnolias, sweet gums and sycamores, which are the pride of our Eastern forests. This fertile land also sustained a fauna corresponding in richness and interest to its flora; for in the Tertiary the gigantic reptiles of the Mesozoic were succeeded by herds of mammals which far surpassed in numbers, size, and variety of species, any mammalian fauna now living. Their remains have been exhumed by thousands from the old lake-beds, where, in the long lapse of ages, they had been borne by river-floods and entombed. Thus were formed the vast charnel-houses from which Leidy, Marsh, and Cope, have drawn the treasures they have exhibited to the admiring scientific world. One after another of those great Tertiary lakes were created by topographical changes which established hydrographic basins, and, in turn, by the cutting down of their outlets, their beds were first made dry land, and afterward deeply cut by the many-branched draining streams, until they have formed the *Mauvaises Terres* or "Bad Lands" of the West.

The Tertiary deposits, then, of the region west of the Mississippi are fresh-water sediments, chiefly the immediate wash of the land, containing fossils which represent not only the fishes and turtles which were their aquatic inhabitants, but the flora and fauna that lived upon their banks.

On the west, however, this lake country was bordered by a chain of volcanoes, which had from time to time their paroxysms of activity,

deluging the lowlands with lava-floods, or discharging into the atmosphere clouds of ashes which, borne far eastward by the prevailing winds, were the agents of more widespread and scarcely less complete devastation. In the end the elevation of the Rocky Mountains, and the erosion of the cañons of the Columbia, Klamath, Sacramento, and Colorado, converted the greater part of the rich Tertiary plain into the only real deserts that now exist on the continent.

Through the center of the region where these great changes were wrought, the belt of the fortieth parallel survey stretches continuously for 750 miles, and yet does not reach near to its eastern border, while it covers but an insignificant portion of its north and south extent. It is evident, therefore, that but a small portion of the records which form the history of the Tertiary ages in Western America come within the limits of Mr. King's survey, but he has made wide excursions both north and south of his special field, and has availed himself of the observations of his co-laborers in Western exploration, so that he has been able to write this history much more fully than had before been attempted.

The following brief summary is all we can give of the most important points in the chapter on the Tertiary rocks, perhaps from its facts and suggestions the most interesting of any in Mr. King's report. During the Eocene four great lakes with different boundaries, and forming different series of sediments, occupied the middle portion of the fortieth parallel belt. These are named by Mr. King: 1. *Ute Lake*, in which the Vermilion Creek beds, 5,000 feet in thickness, accumulated, and which filled the Green River basin to the width of 150 miles, reaching to that distance north of the fortieth parallel, and to a yet unmeasured distance southward; 2. *Gosiute Lake*, from which were deposited the "Green River Beds" of Hayden (the Elko Group of King), 2,000 feet in thickness, which extended westward to the longitude of 116°, and eastward, perhaps, into Middle Park; 3. *Washakie Lake*, in which the Bridger Beds, 2,500 feet thick, were deposited; this occupied the country about Fort Bridger, reaching some 150 miles east and west, and to an unknown distance north and south; 4. *Uintah Lake*, a limited body of water south of the Uintah Mountains, which received the last Eocene sediments, a thin group of clays and sands containing fossils, differing from those of the Bridger Group.

In the Miocene age, the area occupied by the Eocene lakes was mostly dry land, but other lakes not less extensive, and perhaps of equal duration, occupied contemporaneously portions of Nevada and Oregon in the west, and a wide district in the great plains on the east. To the western lake Mr. King gives the name of *Pah-ute*, and its deposits he calls the Truckee Group. The eastern Miocene lake he calls *Sioux Lake*, and its basin contains the strata named by Hayden the White River Group. In the Pliocene a wide extent of the Great Basin was occupied by what Mr. King has named the *Shoshone Lake*, and

its sediments the Humboldt Group. In the middle province was a smaller body of water called the *North Park Lake*, of which the area is underlain by beds to which the same name has been given by Hague and Hayden, while in the region of the Great Plains the Niobrara Group of Marsh was laid down in what King terms the *Cheyenne Lake.*

The details of the description of these Tertiary lakes, and of the history of their formation and disappearance, are among the many things which Mr. King's volume contains, that for want of space must be passed without notice.

Quaternary.—One of the most interesting chapters in Mr. King's volume is that which describes the records of the Quaternary age in the region which he surveyed. The salient points in this history are briefly as follows: Along the fortieth parallel in the far West during the glacial period there was no general glaciation, no continental ice-sheet, but glaciers formed on all the more important mountain-ranges, extending down from their summits to the level of from 6,000 to 9,000 feet above the sea. Traces of these ancient glaciers are seen in excavated lake-basins, glaciated valleys, and terminal and lateral moraines. The glaciers of the Uintah Mountains were by far the most important in all this region. Snow and ice crowned the Park and Medicine Bow Ranges, and extended down all the valleys which radiated from them; but the ice-covered area was small as compared with the great breadth of the country. The Uintah Mountains, however, according to Mr. King, then formed a broad-topped table-land 17,000 or 18,000 feet above the sea, all of which was one great ice-field, with local glaciers descending the valleys both toward the north and south. The whole length of the range was thus covered, and the ice-field had a north and south width of some fifty miles. Thus it formed a glacial area considerably larger than that of the Alps at present. West of the Great Basin, as we know from the reports of King and Le Conte, the Sierra Nevada was the theatre of glacial action on a still grander scale.

The topographical changes in the far West during the Quaternary age seem to have been numerous, but not consequent upon great disturbances, although this unquiet region has shown more or less of its instability to the present day. The changes which would most strike an observer were variations in the water-surface; for Mr. King, joining his observations to those of G. K. Gilbert, has shown that even as late as the Quaternary the Great Basin was a well-watered country, and contained two lakes, which in magnitude were scarcely exceeded by any of those now existing on the continent. Of these, one called by Gilbert *Lake Bonneville*, occupied the Great Salt Lake Valley, with a vast extension toward the south and west. Great Salt Lake occupies the deepest portion of its basin, and, with Utah and Sevier Lakes, represents the residue of its water after a long period of dryness, during which the evaporation exceeded the precipitation. The other great Quaternary lake of this region has been named by Mr. King *La Hon-*

tan ; it occupied western Nevada with an area nearly equal to that of Lake Bonneville, but more broken with islands and promontories. It is now represented by Pyramid, Carson, and Walker's Lakes.

These two Quaternary lakes were, of course, the products of ages during which the precipitation of moisture in the Great Basin was much larger than now ; but Mr. King states that the complete history of the climatic changes in this region during the Quaternary included two moist periods with a dry interval between them, and that these have been succeeded by another interval of aridity, that of the present. Gilbert had previously shown that a period of dryness had preceded the moist period in which Lake Bonneville was filled ; and Mr. King's study of Lake La Hontan indicates another period of humidity which preceded that. The reasoning by which he reaches this conclusion is extremely ingenious, and is based upon the varying chemical precipitates from the waters of Lake La Hontan. In past times the waters which drained into this lake were highly charged with carbonate of soda, and during periods when the lake-waters were concentrated by evaporation, Gaylussite, the hydrated double carbonate of lime and soda, was deposited in sheets on its sides. At other times, when the volume of water was greater, the soda was dissolved out, and carbonate of lime alone precipitated in pseudomorphs after Gaylussite. From facts of this character, which we have not space to present in full, he feels warranted in stating—1. That the lake was formed in a period of abundant precipitation, and had free drainage to the ocean ; 2. In a period of desiccation, the level of the lake was reduced by evaporation below its outlet, and the saline contents concentrated to the point of formation of Gaylussite ; 3. The coming on of a second flood-period which filled the basin to its point of overflow, when the soluble salts were all washed out and the pseudomorph thinolite was formed ; 4. A modern rapid desiccation which nearly emptied the lake-basin, leaving only a few small, weakly saline lakes as its representatives. Mr. King connects these periods of greater precipitation with two corresponding periods of glacial extension, and from these facts hints rather than asserts that elsewhere, as well as there, *superabundant moisture* was the cause of glacial extension, and therefore of those records which are generally regarded as proofs of a cold period. A discussion of the phenomena and causes of the "Ice period" would be incompatible with the limitations of this paper, but we may say in passing that the generalization which has been suggested by Mr. King seems hardly warranted by the facts he reports. It is certainly true that there could be no formation of ice or glaciers, however low the temperature, without precipitated moisture, and in many places the extension of glaciers is limited not by temperature, but by lack of moisture ; but, to find standards of comparison with the widespread glaciers of the Ice period, we must go to the Arctic and Antarctic Continents. Here we are far removed from the theatre of most active evaporation, and where the

climate is very *cold*, and yet the precipitation is sufficient, with the average temperature, to form continental glaciers of equal dimensions with any indicated by the records of the past, and, so far as we can judge, no other condition is necessary for the extension of the glaciers of Greenland southward to Labrador, the Canadian highlands, and the hills of New England, than a depression of temperature sufficient to congeal and retain the moisture which now flows away nearly as fast as it falls. With the arrest of the flow of the St. Lawrence, for example, and its accumulation year after year as ice and snow, it would not require many centuries to pile the ice as high on the Canadian highlands as it was in the Quaternary age.

In Chapter VI., which forms a *résumé* of the stratigraphical geology, Mr. King refers in his graphic and felicitous way to the conditions of deposition of the 120,000 feet of sedimentary accumulations which form the different groups we have reviewed. The tabular presentation of the stratigraphy (page 544), giving at one view the relations of the 50,000 feet of Archæan, 32,000 feet of Palæozoic, 30,000 feet of Mesozoic, and 15,000 feet of Cenozoic rocks, is the most comprehensive and impressive section which has ever been published, and one that shows at a glance the magnitude of the task which Mr. King has performed in the correlation and coördination of such a vast amount of material.

In the last two chapters of his volume Mr. King discusses at great length the genesis and relations of the Tertiary volcanic rocks, and more briefly the classification of the mountain-ranges and lines of upheaval which traverse his field of exploration. These chapters, though of great interest to the geologist, will perhaps not attract the general reader. We would, however, specially commend them to students of lithology and physical geology, as they contain a vast amount of valuable information on what have been made subjects of special study by Mr. King. There was no part of his duty for which he was better prepared than that he has done here; and perhaps none in which he has acquitted himself more creditably. The most striking generalization which he makes in this part of the book, we are, however, compelled to question. This is a new theory of the origin of vulcanism. Most geologists of the present day believe that the crust of the earth is thicker than was once supposed, and that its thickness is increased by the effect of pressure which holds in coerced rigidity a zone of greater or less depth, which is heated above the point at which it would fuse and flow under the pressure of the atmosphere only, and that local relief of this pressure would permit a greater or less mass of highly heated matter below to burst into fluidity, and perhaps find its way to the surface. Mr. King proposes *erosion* as a sufficient cause for the relief of pressure and the production of volcanic phenomena; but some facts suggest themselves which seem to be incompatible with this theory, viz.: 1. Erosion is so slow—on an average 3,000 years

being required to remove a foot of surface—that solidification by cooling must keep pace with it; 2. Volcanoes are generally not situated in areas of erosion, but along coast-lines and on islands; and, 3. They are conspicuously associated with lines of fracture and elevation.

A simple explanation of the phenomena of vulcanism is suggested by the writer, and that is—the relief of pressure by *slight* arching of the crust of the earth along lines of elevation, while the pressure is maximum under the unbroken areas on either side. This unequal pressure would cause a flow of liquid or viscous matter toward and upward under the mountains that mark the lines of arch and fracture, and would permit heated matter held in solidity by pressure to assume the fluid state.

Mallett's theory, that the arching of plates of the earth's crust, and the arrest of their motion in falling, would generate heat sufficient to liquefy masses of rock, and produce volcanic eruptions, is rejected, for the reasons that the strain on arches of sufficient magnitude would be too great for the resistance of the materials composing them, and as Mr. Fisher argues, the heat generated by this method, even if great enough, would not be localized.

Mallett's theory was framed to account for vulcanism *in the crust of the earth*, on the supposition that the crust was very thick, as claimed by Hopkins, Thompson, and Darwin, but Henessey and Delaunay have clearly shown that the investigations supposed to demonstrate the great thickness of the crust are valueless and irrelevant, as the premises assumed are not those of nature, and that we have as yet no evidence of such thickness of crust as would make it impossible for volcanoes to be fed from a general molten mass below the earth's solid crust.

In conclusion, we take pleasure in commending the numerous maps and plates which embellish these elegant volumes. No other scientific work known to us has so many, nor any more artistic or better adapted to supplement and illustrate the text.

A STUDY IN LOCOMOTION.*

By Professor E. J. MAREY.

If the interest of a scientific expositor ought to be measured by the importance of the subject, I shall be applauded for my choice. In fact, there are few questions which touch more closely the very existence of man than that of animated motors—those docile helps whose power or speed he uses at his pleasure, which enjoy to some extent his

* "Animated Motors: Experiments in Graphical Physiology." A lecture delivered at the Paris meeting of the French Association, August 29, 1878.

intimacy, and accompany him in his labors and his pleasures. The species of animal whose coöperation we borrow are numerous, and vary according to latitude and climate. But whether we employ the horse, the ass, the camel, or the reindeer, the same problem is always presented: to get from the animal as much work as possible, sparing him, as far as we can, fatigue and suffering. This identity of standpoint will much simplify my task, as it will enable me to confine the study of animated motors to a single species: I have chosen the horse as the most interesting type. Even with this restriction the subject is still very vast, as all know who are occupied with the different questions connected therewith. In studying the *force of traction* of the horse, and the best methods of utilizing it, we encounter all the problems connected with teams and the construction of vehicles. But, on a subject which has engaged the attention of humanity for thousands of years, it seems difficult to find anything new to say.

If in the employment of the horse we consider *its speed* and the means of increasing it, the subject does not appear less exhausted. Since the chariot-races, of which Greek and Roman antiquity were passionately fond, to our modern horse-races, men have never ceased to pursue with a lively interest the problem of rapid locomotion. What tests and comparisons have not been made to discover what race has most speed, what other most bottom, what crossings, what training give reason to expect still more speed?

Lastly, as to what is called the exterior of the horse, and his varied paces, specialists have for long devoted themselves to this department. The horseman is trained to distinguish between these different paces, to correct by the education of the horse those which seem to him defective, to fix by habit those which give to his mount more pleasant reactions or a much greater stability. The artist, in attempting to represent the horse, seeks to transfer his attitudes more and more faithfully, to express better and better the force, the suppleness, and the grace of his motions.

These questions, so complicated, I wish to bring before you by a new method, and I hope to show you that the *graphic method* makes light of difficulties which seem insurmountable, discerns what escapes the most attentive observation; finally, it expresses clearly to the eyes and engraves upon the memory the most complicated notions. The graphic method was almost unknown twenty-five years ago; to-day it is widespread. Thus, in almost all countries, recourse is had to the employment of graphic curves as the best mode of expression to represent clearly the movement of administrative, industrial, and commercial statistics. In all observatories apparatus known as *registering* or *recording*, trace on paper the curves of variation of the thermometer, the barometer, rain, wind, and even atmospheric electricity. Physiology utilizes still more largely recording apparatus; but I shall only require to show you a very small number of these instruments, those

which serve to record forces, rates of speed, or to note the rhythms and the relations of succession of very complicated movements:

1. *Of the Force of Traction of the Horse, and the best Means of utilizing it.*—When a carriage is badly constructed and badly yoked the traveler is jolted, the road is injured, the horse is fatigued more than is necessary, and is often wounded by parts of the harness. Science and industry have long sought to discover these inconveniences, to find out their causes in order to get rid of them. But it is only in our own time that great progress has been made in this respect. When we complain of being jolted in a humble cab, we ought to go back in thought to the time when people knew nothing of the hanging of carriages. No roughness of the road then escaped the traveler. A Roman emperor mounted on his triumphant chariot was, in the midst of his glory, as ill at ease as the peasant in his cart. Except some improvements, such as the use of softer cushions, things went on thus till the invention of steel springs such as are now employed, for the leather braces of old-fashioned carriages still left much to desire.

Does this mean that the present mode of suspending carriages by four and even eight springs is the final step of progress? Certainly not. Our present springs diminish the force of jolts, transform a sudden shock into a long vibration; but the perfect spring ought always to maintain a constant elastic force, to allow wheels and axles all the vibrations which the ground demands of them, without allowing any of these shocks to reach the carriage itself. The search for this ideal spring has engaged the attention of one of our most eminent engineers. M. Marcel Deprez has found happy solutions to the problem of perfect suspension; he will doubtless soon apply these in practice.

A good suspension also saves the carriage by suppressing the shocks which put it out of order and destroy it in a short time. Finally, suspension saves the wheel itself. On this subject let me recall a remarkable experiment of General Morin. On a high-road, in good condition, he drove a diligence with four horses at the trot, and laden with ballast instead of passengers. The springs of the vehicle were raised so that the body rested on the axles. After the diligence had passed and repassed a certain number of times, it was found that the road on which it was running was notably deteriorated. The springs of the carriage were replaced and the same movements were repeated on another part of the road; the marked deterioration was no longer produced. It is thus clearly proved that a good suspension is favorable to a good condition of the road.

But with non-suspended vehicles, in order thus to shock the passengers, disjoint the carriage, and abuse the road, force is necessary. It is the horse which must supply this; so that, independently of the useful work which we demand of them, the animal supplies still other work which gives rise to a multitude of shocks, and has only injurious

effects. The employment of suspending springs has rendered the double service of suppressing injurious vibrations and of collecting into a useful form all the work which they represent.

Is this all? Do there not remain, even with the best carriages, other vibrations and other shocks which must be pursued and destroyed in order to render more perfect the conditions of traction? You have all experienced, at the moment of the sudden start of a carriage, and even at each stroke of the whip on a living horse, horizontal shocks which sometimes throw you to the bottom of the carriage. In a less degree, shocks of the same kind are produced at each instant of traction, for the speed of the horse is far from being uniform, and the traces are subjected to alternate tension and slackness. Here are veritable shocks which use up part of the work of the horse in giving only hurtful effects which bruise and contuse the breast of the animal, injuring his muscles, and, in spite of the padding of the collar, sometimes wounding him. To prove the disadvantages of this kind of shocks, some experiments are necessary. I have borrowed one from Poncelet; it is easily made, and any one may repeat it. I attach a weight of five kilos to the extremity of a small string; taking hold of the free extremity of this, if I gently raise the weight, you see that the cord resists the weight of five kilos and holds it suspended. But if I attempt to raise the same weight more rapidly, I bruise my fingers, the cord breaks, and the weight has not budged. The effort which I have made has been greater than the preceding, since it has exceeded the resistance of the cord; but the duration of this effort has been too short, and, the inertia of the weight not being overcome, all my exertion has been expended in injurious work. If, instead of an inextensible cord, I had attached to the weight a cord a little extensible, the sudden effort of elevation which I made would have been transformed into an action more prolonged, and the weight would have been raised without breaking the cord and bruising my fingers. To render the phenomenon more easy of comprehension, I shall make a new experiment under conditions a little different.

You see on a vertical support (Fig. 1) a sort of balance-beam, which bears on one of its arms a weight of one hundred grammes, on the other a weight of ten grammes suspended at the end of a cord one metre long. Between these two unequal weights the beam is maintained by a spring-catch, which prevents it from falling to the side of the heavier weight, but which, on the other hand, permits the beam to incline in the opposite direction, if we bring to bear on the end of the cord an effort greater than the weight of one hundred grammes. But, by letting the smaller weight fall from a sufficient height, at the moment when this reaches the end of its course, it will stretch the cord which holds it, and will develop what is called a *vis viva*, capable of raising the weight of one hundred grammes to a certain height; but this elevation will only take place on condition that the applica-

tion of this force does not give rise to a shock. If the cord which sustains the weight of one hundred grammes is inextensible, and if that which bears the weight of ten grammes is the same, at the moment of the fall of the latter, you will hear a snap; a shock agitates the whole apparatus, but the weight of one hundred grammes is not raised.

Now suspend this weight of one hundred grammes to an India-rubber cord or an elastic spring, and repeat the experiment. You see, each time that the weight falls, that the hundred-gramme weight is raised to a certain extent. But this elevation is effected under pecu-

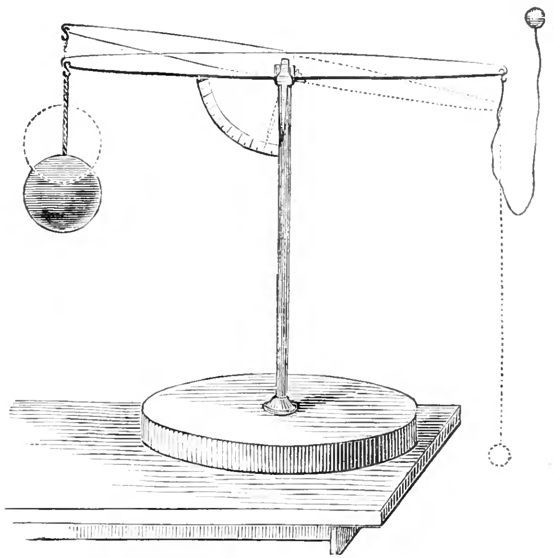

FIG. 1.—Apparatus to show that a *vis viva* directly applied to the displacement of a mass is lost in a shock, while the same force transmitted by an elastic medium may perform work.

liar conditions. At the moment when the weight falls and the cord is stretched, the balance inclines, stretching the elastic spring, but the mass of one hundred grammes does not yet move; it is only when this spring is stretched that the mass, obedient to the prolonged action of this elastic spring, begins to move and rises, representing a certain amount of work accomplished.

Thus the suppression of shock in traction economizes a certain part of the moving labor; it is *then* advantageous to give to the traces of a carriage a certain elasticity. One of the most simple methods consists in interposing between the trace and the carriage an elastic medium. Here are some of these elastic pieces, which I call *tractors*. One of the patterns has been made by M. Tatin; it is composed of a spring which is compressed by traction and deadens the shock. The other is formed of a similar spring placed in the very inside of the carriage-trace.

If you wish to be convinced of the advantage of this mode of traction, yoke yourself to a hand-barrow by means of a rigid leather strap, such as you see used in the streets of Paris or London, where too often man is employed to drag burdens. When you have well noted the painful shocks which this mode of traction transmits to the shoulders, place between the strap and the barrow the elastic tractor and repeat the experiment. After that no doubt is possible; the shoulders are no longer bruised by the shaking of the pavement, and a comfort is experienced which will evidently be experienced in the same degree by a horse placed in conditions of elastic traction.

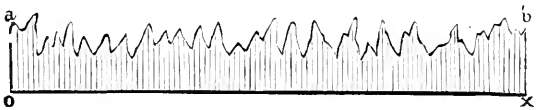

FIG. 2.—Tracing of the dynamograph for a vehicle drawn by a horse.

To obviate suffering of men and animals is unfortunately not a motive sufficient to induce everybody to modify the old system of harnessing. To certain minds known as *positive*, it is necessary to prove that elastic traction has economical advantages, and that a horse thus harnessed is able to draw heavier loads. This fact, which results from the experiments you have seen, requires to be rigorously proved by the aid of the graphic method. It is to the genius of Poncelet that we owe the record of work expended by different motors.

Everybody knows what a dynamometer is, viz., a spring which, yielding to tractions exerted upon it, is deformed in proportion to the efforts developed. Let us adapt to a spring of this kind a pencil which touches a strip of paper, and let us so arrange things that the movements of the wheel of a carriage shall impress upon the paper a motion of translation. While the effort of traction of the horse will communicate to the spring movements more or less extended, the progress of the carriage will draw out the paper, and from these combined movements will result a curve (Fig. 2), which can be resolved into a series of ordinates or vertical lines in juxtaposition, expressing by their unequal heights the series of efforts resulting from each element of the road traversed. The sum of these elementary efforts, otherwise the surface of paper limited in height by the flexures of the curve, will be the measure of the work expended. If we record in a comparative manner the work done by the same vehicle harnessed with rigid traces or supplied with elastic tractors, we see (Figs. 3 and 4) that the *area* of the curve is greater, that is, that there has been more work expended, while rigid traces have been used. In the most favorable cases that I have met with, the economy of work by elastic traction has been twenty-six per cent.

But, it may be objected, the recording dynamometer itself consti-

tutes an elastic intermediary which suppresses the shocks. But it is not the ordinary dynamometer which I have used in my experiments, but a special dynamometer which undergoes under the strongest tractions only an almost insignificant elongation. This elongation, amplified by certain organs and transmitted to a distance by a lever fitted

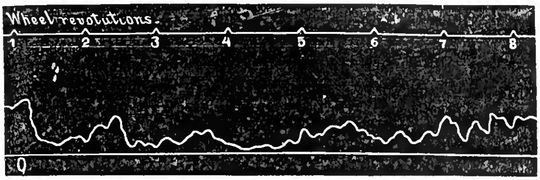

FIG. 3.—Tracing of the dynamograph for a vehicle drawn with an elastic intermediary.

with a pen, is recorded in the form of a wavy curve in conditions referred to above. To sum up, in the employment of animated motors for the drawing of burdens, to find out wherever they produce shocks and vibrations, and to absorb them in elastic springs which restore to useful work a force that seemed only to destroy vehicles, tear up the

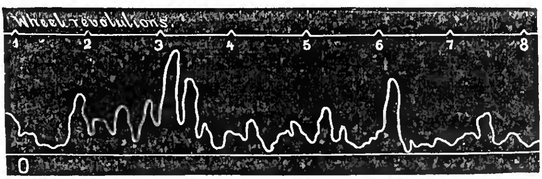

FIG. 4.—Tracing of the dynamograph for a hand-barrow drawn by a rigid trace.

roads, cause the animals to suffer—such is the direction in which much progress has been realized, and much more may still be realized.

2. *Of the Speed of Animated Motors.*—I shall perhaps astonish many of you by saying that the speed of a vehicle is one of the things most imperfectly known. It is generally believed to be sufficiently expressed by stating how much way has been made and how much time has been occupied for that. I have come, you may say, from the Pont de Sèvres to the Madeleine in $41\frac{1}{4}$ minutes; the road is well mile-stoned, I possess a good watch; what greater precision do you require? Assuredly you have measured accurately the space traversed and the time employed, but that constitutes only the expression of a mean speed resulting from a series of variable speeds, of accelerations, of retardations, and sometimes of stoppages where time is quite unknown. A rigorous measurement of rates supposes the road traversed by the vehicle at each instant; in other words, the position which it occupies upon the road. It is thus that physicists have determined the accelerated motion of the fall of bodies—Galileo and Atwood, by means of successive measurements, Poncelet and Morin by means of that ad-

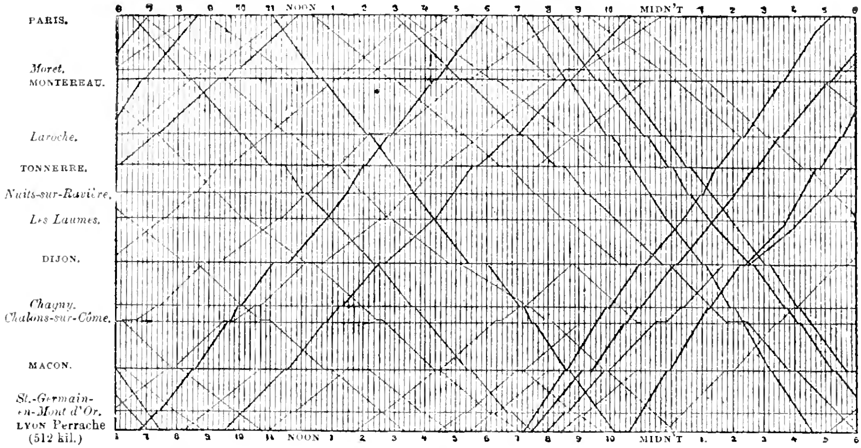

FIG. 5.—GRAPHIC OF THE PROGRESS OF TRAINS UPON A RAILWAY, AFTER IBRY'S METHOD.—When we place the figure before us we read from the left, on the axis of the ordinates, the series of stations, that is, the divisions to be run over; the distance between the stations on the paper is proportional to the kilometric distances which separate them. In the horizontal direction, that is, on the axis of the abscissæ, are counted the divisions of time in hours, themselves subdivided into spaces of ten minutes each. The breadth of the table is such that the twenty-four hours of the day are represented on it, commencing at 6 A. M., and ending next day at the same hour. If we wish to express that a train is on a certain point of the line at a certain hour, we shall point out its position on the table, opposite the station or any point of the line which it occupies, and on the properly chosen division of time. A single point of the table satisfies these conditions. At successive instants the train will occupy points on the table always different; the series of these points will give rise to a line which will be descending and oblique from left to right for trains coming from Paris, while it will be ascending and oblique in the same direction for trains going to Paris. The line which corresponds to each of the trains expresses the hours of departure and arrival, the relative and absolute rates of the trains, the instant of passing each of the stations, and the duration of stoppages. In fact, if we consider any particular train, we see that a train starts from the station at Paris at 11 A. M.; if we follow this train in its progress, we find that it has seven stoppages (during which it is not displaced in space, but only in time). These stoppages are translated by the horizontal direction of the line, opposite the station where they take place; the length of this horizontal line measures the duration of the stoppages. The line of the train, followed to the end, shows that the arrival takes place at 6 P. M.; but, if we reckon the distance on the axis of the ordinates, we see that 512 kilometres have been traversed in eleven hours ten minutes, stoppages included, which gives a mean rate of about forty-six kilometres per hour.

mirable apparatus which traces by a single stroke the curve of a movement.

This machine is now too well known to need description; however, I shall make it work before you in order to interpret its language and to show how a graphic curve translates all the phases of a movement. The parabolic curve traced expresses for each of its points the position in which the body is found at each of the instants of its fall; it thus supplies the most complete information on the nature of the movement. But if, knowing only the space run over and the time employed, we join the two extreme points of departure and arrival by a straight line, that line which will express the mean rate of the fall will not correspond to any of the rates which the body has successively possessed.

The expression of movement by a curve has been put into practice. An engineer named Ibry has devised a method of representing graphically the progress of trains upon a railway. This mode of representation, incomparably more explicit than the tables of figures of our railway *indicators*, has not yet got into the hands of the public; and

this is to be regretted, for it gives a genuine interest to a journey, as you may see by inspection of one of these graphics.

The table which you see (Fig. 5) is prepared by engineers according to the regulation progress of trains, a progress supposed uniform; we see, in fact, that the lines of progress are all straight, joining to each other the two points which express the place and time of departure, the place and time of arrival. It does not then take into account the real movement of the train, which is accelerated or retarded under a great number of influences. The problem which we seek to solve, that of a graphic expression of the real rate of a vehicle, supposes that the carriage itself traces the curve of the roads traversed in function of time. By means of the apparatus which I present to you, and which I call the *odograph* (Fig. 6), a wagon or any kind of carriage traces the curve of its movement with all its variations.

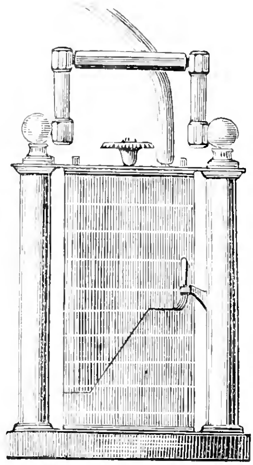

Fig. 6.—Odograph, reduced to one third of its diameter.

This apparatus, based on the same principle as the Poncelet and Morin machine, is composed of a tracing style which moves parallel to the generatrix of a revolving cylinder covered with paper. The movement of the style follows all the phases of that of the carriage, but on a very reduced scale, in order that the tracing of a distance of several myriametres may be contained in the dimensions of a sheet of paper. As to the movement of the cylinder, it is uniform, and commanded by clockwork placed in the interior. In order that the movement of the style may be proportional to that of the vehicle, things have been so arranged that each turn of the wheel causes the style to advance by a small quantity always the same. But as a turn of the wheel always corresponds to the same distance accomplished, the faster the vehicle travels the more turns will the wheel make in a given time, and the more movements of progression will the style undergo. This solidarity between the movements of the wheel and those of the style is obtained by means of a small eccentric placed on the vane. At each turn there is produced a puff of air which, by a transmitting tube, causes a tooth of the wheel of the apparatus to escape, and the style to advance by a small quantity. Similar effects may be obtained by means of electro-magnetic apparatus. Thus the swifter the vehicle goes the more rapidly will the line traced ascend; the comparative slope of various elements of the tracing will express the variations of rate, as seen in Fig. 7.

If we wish to learn the absolute value of time and distance, it is sufficient to know that each minute corresponds to a millimetre counted horizontally on the paper, and that each kilometre corresponds to a

certain number of millimetres traversed by the style in the vertical direction. The course of the style, which corresponds to a kilometre, ought to be experimentally determined for each vehicle, for the perimeter of wheels is not always the same. But it is clear that, if from each kilometre-stone to another we obtain five millimetres, for example, for the course of the style, this length will always be found to be traversed each kilometre by the same vehicle. Our apparatus is then a measurer of distances, and dispenses with the necessity of attending to

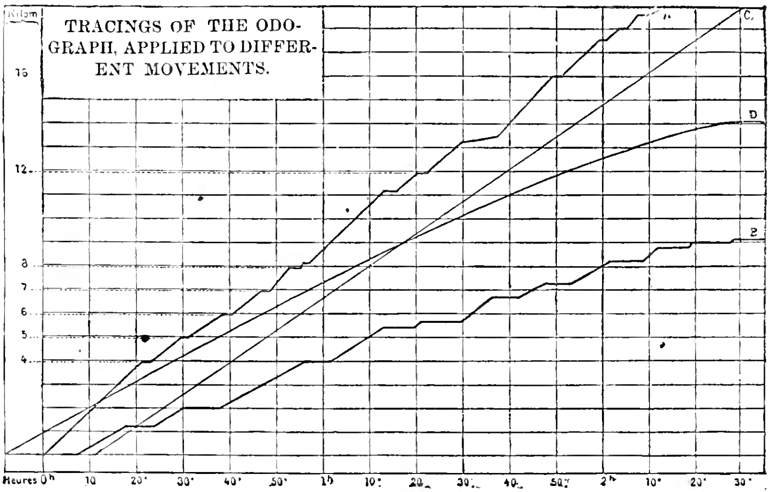

FIG. 7.—TRACINGS OF THE ODOGRAPH: A, rapid coach with stoppages; B, slow coach; C, gas meter, frequency of turns of the wheel; D, curve of the turns of a clock wheel-work with fly.

the existence of kilometre-stones; it enables the distance traversed on any road whatever to be estimated, and even when there is no beaten track. Thus in a journey of discovery we may measure the distance traversed by a cart. To remain in the conditions of ordinary life, have we not sometimes in the country a choice of two or three roads to go from one place to another? To know which is the shortest we appeal to the watch, as if the least duration of a walk corresponded to the least distance. The odograph will give in this respect very precise information.

There are again a great number of questions which we ask daily without being able to solve them. Does such a draught-horse go quicker than such another? Does this trot better to-day than yesterday? By increasing the ration of oats do we increase speed? Compare the slope of two curves of rates, and you will have the reply to all these questions without being obliged to make special experiments on a measured road, watch in hand.

It is not only to the speed of vehicles that the registering apparatus applies; it traces, though with less precision, the rate of progress of

men and animals. We slip into our boots a bellows-sole, which is connected by a tube with a portable odograph. Each pace impresses on the style a small movement, as does each turn of the wheel of a carriage; and, if the paces be absolutely equal, we may measure with certainty the distances traveled. In walking on level ground we take steps of astonishing regularity; but, if the ground rises, the step gains in length; in descents, on the contrary, the steps are shortened. There may result from this slight errors in the distances traversed. Notwithstanding this, the employment of this apparatus will effect a great progress; it may be substituted with many advantages for the pedometer, which gives at the end of a certain time only the paces accomplished, without taking count of the stoppages or the changes of rate.

In short, when we make an experiment on a measured road, if there are produced variations in the length of the tracing represented by a kilometre, we conclude therefrom variations in the length of the pace. Such variations are observed under the influence of the slope of the country, the nature of the soil, the boots we wear, the rate of walking, or the weight carried. These studies in applied physiology have, I believe, a great practical importance, and numerous applications to the march of troops in a campaign.—*Nature.*

JOHN STUART MILL.

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II.

HAVING no more documents until 1830, I propose to make a short critical review of Mill's writings and doings in the interval, upon the basis of the information supplied by himself. I will first endeavor, for the sake of clearness, to extract the chronological sequence of the years from 1820 to 1830, which, from his plan of writing, is not very easy to get hold of.

1821. Returns from France (July). Beginning of psychological studies. Condillac.

1822. Reads the History of the French Revolution; inflamed with the subject. Studies law with Austin. Dumont's Bentham excites him to a pitch of enthusiasm. Locke, Helvetius, Hartley, Berkeley, Hume, Reid, Dugald Stewart, Brown on Cause and Effect, Bentham's Analysis of Natural Religion. Began intimacy with Grote. Charles Austin. First published writings in the "Traveller" newspaper.

1823. Utilitarian Society at Bentham's house: Tooke, Ellis, and Graham. Appointment to India House (May 21st). Letters to the

"Morning Chronicle" on the Richard Carlile prosecution (January and February). Frequent contributions throughout the year to the "Chronicle" and "Traveller." "Westminster Review" projected. Reads up the "Edinburgh Review" for his father's attack upon it in the first number of the "Westminster."

1824. First number of the "Westminster" appears (March). Contributes to the second number on the "Edinburgh Review"; to the third on "Religious Persecution" (?) and "War Expenditure"; to the fourth on "Hume's Misrepresentations in his History."

1825. Principal occupation, editing Bentham's book on Evidence. Starting of "Parliamentary History and Review"; writes the article on the "Catholic Disabilities"; also, on the "Commercial Crisis and Currency" and the "Reciprocity Principle in Commerce." Learned German. Began morning-readings in the Society at Grote's house in Threadneedle Street. Went with some others to the debates of the Owenites' Coöperative Society; founding of the Speculative Debating Society. In the "Westminster," wrote on the "Political Economy of the Quarterly," on the "Law of Libel" (?), and on the "Game Laws" (?) (number for January, 1826).

1826. Utilitarian Society ceases, and readings at Grote's continue. Speculative Society flourishing. Reviews for the "Westminster," Mignet's "French Revolution," and Sismondi's "History of France"; writes two articles on the Corn Laws; replies to the "Quarterly" on "Greek Courts of Justice." Beginning of "mental crisis."

1827. Speculative Society. Readings at Grote's (turned now to Logic). Articles in the "Westminster"; review of Goodwin's "Commonwealth" (?); of Whately's Logic (in number for January, 1828).

1828. Speculative Society. Readings at Grote's, on his father's "Analysis." Last article in "Westminster"—Scott's "Life of Napoleon." Acquaintance with Maurice and Sterling. Read Wordsworth for the first time. (At some later return of his dejection, year not stated, he was oppressed with the problem of philosophical necessity, and found the solution that he afterward expounded in the "Logic.") Is promoted from being a clerk to be assistant examiner in his office.

1829. Withdrew from Speculative Debating Society. Macaulay's attack on "Essay on Government" produces a change in his views of the Logic of Politics.

With regard to these nine years, I will first remark on his articles in the "Westminster Review." He says he contributed thirteen, of which he specifies only three: of the whole, he says generally, they were reviews of books on history and political economy, or discussions on special political topics, as corn laws, game laws, law of libel. I am able to identify the greater number of them.

His first contribution is the article in the second number, on the "Edinburgh Review," which continued the attack made by his father

in the first number; he puts this down as "of little or no value," although to himself a most useful exercise in composition; it is, nevertheless, in respect of his biography, an interesting study. No doubt the opinions are for the most part his father's, though independently and freshly illustrated: the demonstration of the truckling of the "Edinburgh Review" to sentiment and popularity; the onslaught against lubricated phrases; the defectiveness of the current morality as reflected in the "Review"; the denunciation of the pandering to our national egotism: all these were his father *redivivus;* yet we may see the beginnings of his own independent start, more especially in the opinions with regard to women, and the morality of sex.

In the third number (July, 1824) he has an article on "War Expenditure," the review of a pamphlet by William Blake on the recent fluctuations of prices. In the fourth number (October, 1825) he reviews at length a work on English history, by George Brodie, which is especially devoted to Hume's misrepresentations. He enters fully into the exposure of Hume's disingenuous artifices; and at the present time, when Hume's metaphysical reputation is so resplendent, his moral obliquity as an historian must not be glossed over. No doubt his Toryism was his shelter from the odium of his skepticism. Mill says of him: "Hume possessed powers of a very high order; but regard for truth formed no part of his character. He reasoned with surprising acuteness; but the object of his reasonings was not to attain truth, but to show that it was unattainable. His mind, too, was completely enslaved by a taste for literature; not those kinds of literature which teach mankind to know the causes of their happiness and misery, that they may seek the one and avoid the other, but that literature which, without regard for truth or utility, seeks only to excite emotion."

In the fifth number (January, 1825) he assails the "Quarterly" for its review of the Essay on Political Economy in the supplement to the "Encyclopædia Britannica." In the sixth number (October, 1825) there is a long article on the "Law of Libel," the sequel to a previous article on "Religious Prosecutions" (number three), but I have no means of proving them to be his, except that this is one of the topics that he specifies. For the fourth volume, numbers seven and eight, I have no clew. The ninth number (January, 1826) opens with a powerfully written paper on the "Game Laws," which I believe to be his. In the tenth number (April, 1826) there is a short review by him of Mignet's History of the "French Revolution," which is principally occupied with pointing out the merits of the book. I have heard him recommend Mignet as the best for giving the story of the Revolution. He reserves all discussions of the subject; "it being our intention, at no distant period, to treat of that subject at greater length." In the eleventh number (July, 1826) there is a searching discussion of the merits of the Age of Chivalry, on the basis of Sismondi's "History of

France," and Dulaure's "History of Paris"; which is not unlikely to be Mill's. The Corn Laws is one of his subjects, and on this there is an article of thirty pages in the twelfth number (October, 1826). In the following number (January, 1827), there is a second article, referring to Mr. Canning's measure recently brought forward (1826). The concluding article of this number I believe to be Mill's; it deals with a recent article in the "Quarterly," on "Greek Courts of Justice," and is in his happiest vein. It retorts cleverly upon the exaggerations of the "Quarterly," by finding in the English legal practice abuses equal to the worst that the reviewer discovers in the Athenian courts. In the sixteenth number there is a review of Goodwin's "History of the Commonwealth," which seems to follow up the review of Hume.

The article on Whately in January, 1828, was the outcome of the discussions in Grote's house the previous year. It is a landmark not merely in the history of his own mind, but in the history of Logic. His discussion of the utility of Logic, at a time when Syllogism was the body and essence of it, hits the strongest part of the case better than the famous chapter on the "Functions of the Syllogism"; I mean the analyzing of an argument, with a view to isolating the attention on the parts. The discussion of the Predicables is an improvement upon Whately. He even praises, although he does not quite agree with, Whately's attempt to identify Induction with Syllogism, and gives him credit for illustrating, but not for solving, the difficulty of our assenting to general propositions without seeing all that they involve. His view of the *desiderata* of Logic is thus expressed: "A large portion of the philosophy of general Terms still remains undiscovered; the philosophical analysis of Predication, the explanation of what is the immediate object of belief when we assent to a proposition, is yet to be performed; and, though the important assistance rendered by general language, not only in what are termed the exact sciences, but even in the discovery of physical facts, is known and admitted, the nature of the means by which it performs this service is a problem still to a great extent unsolved." On the whole, it can not be said that he had, as yet, made much progress in Logic, even with the assistance of the debates in Threadneedle Street. The real advances apparently remained to be worked out by his own unassisted strength during the next twelve years. I may remark, in conclusion, that I think he greatly overrates the value of Whately's book: "The masterly sketch which he has given of the whole science in the analytical form, previously to entering upon a more detailed exposition of it in the synthetical order, constitutes one of the greatest *merits* of the volume, as an elementary work." If, instead of merits, defects were substituted, the sentence would be, in my judgment, very near the truth. The result of the arrangement was singularly confusing to myself, when I first read the book; and the testimony of all subsequent writers on Logic must be held as against it, for not one, to my knowledge, has ever

repeated it. It grew out of the very laudable desire to approach an abstract subject by a concrete introduction; but the conditions of success in that endeavor have scarcely yet been realized by any one of the many that have made it. At a later period, Grote declaimed strongly against Mill's setting Whately above Hamilton.

The final article in April, 1828, is the review of Scott's "Life of Napoleon." It extends to sixty pages, and is in every way a masterpiece. He had now made a thorough study of the French Revolution, and had formed the design to be himself its historian. He does ample justice to Scott's genius as a narrator, and to a certain amount of impartiality founded on his naturally tolerant disposition, and his aim at winning the good word of everybody. But the exposure of the many and deep-seated defects of the work, both in facts and in reasonings, is complete, and would have marred the fame of any other writer. In point of execution, it is not unworthy to be compared with the Sedgwick and Whewell articles.

I consider some observations called for on the mental crisis of 1826. He had then completed his twentieth year. The subjective description given of his state must be accepted as complete. But the occurrence is treated as purely spiritual or mental; the physical counterpart being wholly omitted; the only expression used, "a dull state of nerves *such as everybody is liable to*," is merely to help out the description on the mental side. Nothing could be more characteristic of the man. There was one thing he never would allow, which was, that work could be pushed to the point of being injurious to either body or mind. That the dejection so feelingly depicted was due to physical causes, and that the chief of these causes was overworking the brain, may I think be certified beyond all reasonable doubt. We know well enough what amount of mental strain the human constitution, when at its very best, has been found to endure; and I am unable to produce an instance of a man going through as much as Mill did before twenty, and yet living a healthy life of seventy years. The account of his labors in the previous year alone, 1825 (a lad of nineteen), is enough to account for all that he underwent in the years immediately following. Moreover, it was too early to have exhausted his whole interest in life, even supposing that he had drawn somewhat exclusively upon the side of activity and reforming zeal. Fifteen or twenty years later was soon enough to readjust his scheme of enjoyment, by delicate choice and variation of stimulants, by the cultivation of poetry and passive susceptibility. It so happened that, on the present occasion, his morbid symptoms were purely subjective; there was no apparent derangement in any bodily organ. Judging, however, from what followed a few years later, we can plainly see in this "mental crisis" the beginning of the maladies that oppressed the second half of his life in a way that could not be mistaken. He got over the attack apparently in two or three years,

with powers of enjoyment considerably impaired. That spirit left him for a time, but returned with another still worse.

Preparatory to the additional elucidation of his life and work from 1830 to 1840, I have constructed the following chronological outline:

1830. Put on paper ideas on "Logical Distinctions among Terms," and the "Import of Propositions." First acquaintance with the French Philosophy of History: St. Simonians; Comte. Went to Paris after the Revolution of July. Began to write steadily on French politics ("Examiner").

1831. Writing in "Examiner": Essays on "The Spirit of the Age."* Essays on "Unsettled Questions in Political Economy" (1830 and 1831, not published till long after). Resumed "Logical Axioms and Theory of the Syllogism." Tide of the Reform Agitation. First introduction to Mrs. Taylor.

1832. Essays in "Tait's Magazine," and in the "Jurist." Papers on "Corporation and Church Property" and the "Currency Juggle."

1833. "Monthly Repository": Review of Alison's "History"; "Thoughts on Poetry"; Analysis of "Platonic Dialogues." In Paris in autumn, and saw Carrel for the first time.

1834. "London Review" projected; Molesworth to be proprietor. No special work recorded.

1835. Read De Tocqueville's "Democracy in America." "London Review": article on Sedgwick.

1836. His father's death. Illness in the head. Three months' leave of absence; tour in Switzerland and Italy. "London and Westminster Review": "Civilization" (April). Is promoted to be second assistant in his office (salary £800), and again to be first assistant (£1,200).

* On looking over the file of the "Examiner," to see the drift of these Essays, which I expected to turn upon social questions, more than politics, I find that they all point in the direction of his "Representative Government," in so far as they contain anything constructive. There is a long *exordium* on the character of the present age, as an age of *transition*, with all the consequences growing out of that—unsettlement of existing institutions, in the absence of principles to found new ones upon. "Worldly power must pass from the hands of the stationary part of mankind into those of the progressive part. . . . There must be a moral and social revolution which shall, indeed, take away no men's lives or property, but which shall leave to no man one fraction of unearned distinction or unearned importance. . . . For mankind to change their institutions while their minds are unsettled, without fixed principles, is indeed a fearful thing. But a bad way is often the best to get out of a bad position. Let us place our trust in the future, not in the wisdom of mankind, but in something far surer, the force of circumstances which makes men see that, when it is near at hand, which they could not foresee when at a distance." Discussing the way to secure government by the fittest, he considers the time is gone by when wealth is the criterion. Age has more to say for itself, excepting in a time of transition. He considers at some length the sources of moral influence on society. The last of the series (May 29th) concludes, "I shall resume my subject as early as possible after the passing of the Reform Bill"; the agitation then going on being used as the climax of the proof that the time is one of transition.

1837. "London and Westminster Review": "Aphorisms" (January); "Armand Carrel" (October).

1838. "London and Westminster Review": "A Prophecy" (January). "Alfred de Vigny" (April). "Bentham" (August).

1839. Illness. Received six months' leave of absence, and traveled in Italy.

1840. "London and Westminster": "Coleridge" (March). "Edinburgh Review": De Tocqueville's "Democracy" (October). With Henry at Falmouth, in his last illness.

He tells us how he was excited by the French Revolution of 1830, and visited Paris in consequence. He wrote on the 13th August a long letter to his father on the state of parties. He begins: "I have had some conversation with M. Say, and a great deal with Adolphe d'Eichthal and Victor Lanjuinais, and I have been a very assiduous reader of all the newspapers since I arrived. At present, if I were to look only at the cowardice and imbecility of the existing generation of public men, with scarcely a single exception, I should expect very little good; but when I consider the spirit and intelligence of the young men and of the people, the immense influence of the journals, and the strength of the public voice, I am encouraged to hope that as there has been an excellent revolution without leaders, leaders will not be required in order to establish a good government." He then goes on to give a detailed account of how the revolution was accomplished —the flinching of the generals of the army, the cowardice and meanness of Dupin above everybody. He has the lowest opinion of the ministry, not a Radical among them except Dupont de l'Eure; all mere place-hunters. Thiers at the meeting for organizing the resistance showed great weakness and pusillanimity. (I heard him long afterward say he detested Thiers.) Of the new measures he praises most the lowering of the age qualification to the Chamber from forty to thirty; he has seen no one that attaches due importance to this change. "I am going to the Chamber of Deputies to-morrow with Mr. Austin, and next week I am to be introduced to the Society of 'Aide-toi,' where I am to be brought in contact with almost all the best of the young men, and there are few besides that I should at all care to be acquainted with. . . . I have heard of an immense number of the most affecting instances of the virtue and good sense of the common people." These last observations are thoroughly characteristic. Young men and *ouvriers* were Mill's hopes.

We learn from himself that he wrote the articles in the "Examiner" on French politics for several years. Even when English politics became all-engrossing, he still maintained his interest and fond hopes in the future of France.

His first bad illness was ten years after the beginning of the period

of dejection in 1826. In 1836, his thirtieth year, he was seized with an obstinate derangement of the brain. Among the external symptoms were involuntary nervous twitchings in the face. Of the inner consciousness corresponding, we have suggestive indications in the family letters of the time. The earliest allusion to his state is contained in his father's first letter to James in India: "John is still in a rather pining way; though, as he does not choose to tell the cause of his pining, he leaves other people to their conjectures." This shows that he had ceased to give his father his confidence in bodily as well as in his mental matters. His medical adviser sent him in the first instance to Brighton. A letter from thence addressed to Henry at home—date not given, but probably near the time of his father's letter—says: "There seems to be a change considerably for the better in my bodily state within the last three days; whether it will last I can not yet tell; nor do I know whether the place has contributed toward it, as the more genial weather of yesterday and to-day is probably the chief cause." He then says that he will continue his stay if the improvement goes on, but is reluctant to be long absent, partly on account of his father's illness, and partly on account of his tutoring "Mary and George." He trusts to Henry to keep him informed on the state of matters, and if he can be of any use to his father he will forego the present advantages and trust to getting well as the summer advances. In a letter, dated 7th May, from Henry to James in India, occurs a further allusion: "There is a new visitor added to the list of young men who come here, a Dr. King, whom John consults about his health" (he afterward married the eldest daughter, but soon left her a widow). John "is certainly ill, but nothing, every one assures us, to be frightening himself about." The father's death occurred soon after (23d June), and on the 29th July Henry wrote: "We are all well in health, except John and myself—John from his old complaint. . . . George and I are going to the Continent with John, who has got leave of absence from the India House for three months on plea of ill-health." In this letter is a postscript: "John has honored me with the present of a watch that was given to my father by Mr. Ricardo; so you see it is trebly valuable to me." This reminds us of John's loss of his own watch; to which I may add that to the end of his life he had only an ordinary silver watch.

Next day, the 30th, the party left London. They traveled in France and Switzerland for a month, and the two boys took up their abode at Lausanne, while John went on to Italy. The expressions as to his state are still (September 4th) very discouraging: "His head is most obstinate; those same disagreeable sensations still, which he has tried so many ways to get rid of, are plaguing him." Three weeks later Henry says: "John wrote to us a very desponding letter, saying that, if he had to go back without getting well, he could not again go to the India House, but must throw it up, and try if a year or two

of leisure would do anything." The same letter incidentally notices that Mrs. Taylor joined the party, and accompanied John in his tour, while the young people remained at Lausanne. We have no further references to this illness; he got round in time, but he retained to the end of his life an almost ceaseless spasmodic twitching over one eye. His renewed capability for work is shown by the dates of his writings immediately subsequent. He had many illnesses afterward, but I do not know that any one was so markedly an affection of the brain as on this occasion.

Two years and a half later, in the beginning of 1839, he went to Italy, and was away six months on sick-leave. The expressions that I shall quote from the correspondence are my only means of knowing the nature and extent of his malady. On January 17th Henry writes: "As to John's health, none of us believe that it is anything very serious; our means of judging are his looks when he was here, and also what we have heard from Dr. Arnott. We are told, however, that his sending him away is because his pains in the chest, which are the symptoms, make it seem that a winter in Italy just now will afford him sensible and permanent benefit for the whole of his life. . . . That this might have turned to gout." The next letter is one from himself, dated Rome, March 11th. He says: "I have returned here after passing about three weeks very pleasantly in Naples, and the country about it. I did not for some time get any better, but I think I am now, though very slowly, improving, ever since I left off animal food, and took to living almost entirely on macaroni. I began this experiment about a fortnight ago, and it seems to succeed better than any of the other experiments I have tried." The remainder of the letter describes Naples and neighborhood—"Pompeii, Baiæ, Pæstum, etc." Ten days later he writes: "As for me I am going on well too—not that my health is at all better; but I have gradually got quite reconciled to the idea of returning in much the same state of health as when I left England; it is by care and regimen that I must hope to get well, and, if I can only avoid getting worse, I shall have no great reason to complain, as hardly anybody continues after my age (thirty-three) to have the same vigorous health they had in early youth. In the mean time it is something to have so good an opportunity of seeing Italy." Again, he writes on May 31st, from Munich on his way home: "I am not at all cured, but I cease to care much about it. I am as fit for all my occupations as I was before, and as capable of bodily exertion as I have been of late years—only I have not quite so good a stomach." He then dilates on the pleasures of his Italian tour, to which he added the Tyrol. He returned to his office-work on July 1st. The only indication of his state is in a letter from Henry: "John is come back looking tolerably well; he is considerably thinner, however." We infer that his primary affection was in the chest, and to this was added

weakness of stomach. In both these organs he was subject to recurring derangements for the rest of his life.*

The "London Review," projected in 1834, started in April, 1835. Sir William Molesworth undertook the whole risk, and Mill was to be editor, although he considered it incompatible with his office to be openly proclaimed in that capacity. His father lent his latest energies to the scheme, and opened the first number with a political article, entitled "The State of the Nation"—a survey of the situation of public affairs in the beginning of 1835, in his usual style. John Mill's first contribution was the Sedgwick article. I have heard that Sedgwick himself confessed that he had been writing about what he did not understand, but my informant was not himself a Cambridge man. Effective as the article was for its main purpose of defending the "Utilitarian Ethics" against a sciolist, it always seemed to me rather weak in the introduction, which consists in putting the question, "For what end do endowed universities exist?" and in answering, "To keep alive philosophy." In his mind, philosophy seemed to mean chiefly advanced views in politics and in ethics; which, of course, came into collision with religious orthodoxy and the received commonplaces of society. Such a view of the functions of a university would not be put forth by any man that had ever resided in a university; and this is not the only occasion when Mill dogmatized on universities in total ignorance of their working.

The second number of the "Review" is chiefly notable for his father's article on "Reform in the Church." It is understood that this article gave a severe shock to the religious public; it was a style of reform that the ordinary churchman could not enter into. The prospects of the "Review" were said to be very much damaged in consequence. John Mill wrote on Samuel Bailey's "Rationale of Political Representation." Bailey's views being in close accordance with his own, he chiefly uses the work as an enforcement of the radical creed. After Bentham and the Mills, no man of their generation was better grounded in logical methods, or more thorough in his method of grappling with political and other questions, than Samuel Bailey.

In the same number Mill reviews Tennyson's poems. He assigns as his inducement that the only influential organs that had as yet noticed them were "Blackwood" and the "Quarterly Review"; on which notices he pronounces a decided and not flattering opinion. He is, accordingly, one of the earliest to mete out justice to Tennyson's powers; and as a critical exercise, as well as a sympathetic appreciation, the article is highly meritorious. In numerous instances besides, Mill was among the first, if not the very first, to welcome a rising genius.

* He took the opportunity of studying Roman history while in Italy; and in Rome itself he read Niebuhr. It was long a design of his to write the philosophy of the rise of the Roman power, but he failed to satisfy himself that he possessed an adequate clew. So late as 1844, or 1845, he was brooding over a review article on this subject.

He closes the number with a political article on the measures of the Government for the session—among others, the Irish Church and the Municipal Corporations bills. His text seems to be that the statesmen of the generation are good in destroying, but bad in construction; and he says that the remark applies to all the Whig reforms, and most of all to Lord Brougham's law reforms.

In the third number (July, 1835) Mill reviewed De Tocqueville's book, which had then appeared—the review extending to forty-five pages. It was a very full account of the book, with copious extracts, but may be considered as superseded by the article written for the "Edinburgh Review" in 1840, which is reprinted in the "Dissertations." The number concludes with a short but energetic review of the Parliamentary session just concluded. It is of the tone and character of all his political writings in those years; a retrospect of recent achievements, with a view of the present position and declaration of the one thing needful for it—a leader. He bitterly complains of the absence of a man of action, and asks: "Why does not Mr. Grote exert himself? There is not a man in Parliament who *could* do so much, or who is more thoroughly the people's friend. . . . O'Connell is the only figure that stands erect." The Liberal press is too much given to truckling to the Ministry. The bull must be taken by the horns; the Tories must be awakened by the apparition of a House of Lords Amendment Bill.

In the fourth number (January, 1836) he had an article entitled "State of Society in America," reviewing a number of books of American travels, and following up the article on De Tocqueville. It is occupied with an attempt to connect the features of American society with the industrial position and political constitution of the country. It may be called one of his minor sociological studies.

The fifth number is the first of the union of the "London" with the old "Westminster," hereafter called "The London and Westminster." It appeared in April, 1836. Mill contributes to it his article on "Civilization," contained in the "Dissertations," and a short political article on the "State of Politics in 1836." I never felt quite satisfied with the article on "Civilization." The definition given at the outset seemed inadequate; and the remainder of the article is principally one of his many attacks on the vicious tendencies of the time. He regards as consequences of our civilization, the decay of individual energy, the weakening of the influence of superior minds, the growth of *charlatanerie*, and the diminished efficacy of public opinion, and insists on some remedies for the evils; winding up with an attack on the universities. To my mind these topics should have been detached from any theory of civilization, or any attempt to extol the past at the cost of the present. The political article is a survey of the measures pending in Parliament. He is very much excited, as his father was, about the spoiling of the country with unnecessary

railways. There is the usual complaint of the torpidity of Radicals, Joseph Hume being his only exception.

For the July number he contributes only the opening article, which is a political survey, on the text of Sir John Walsh's "Contemporary History." It retraces the history of reform and its consequences, and discourses on the relative merits of Tories, Whigs, and Radicals, with the usual complaints. Knowing the state of his health this year, the occurrence of his father's death, and his three months' absence, we are surprised to find that he can contribute to the October number, of which the first article is his, on the "Definition and Method of Political Economy." Doubtless this had been lying by him, and had been brought out to fill a gap.

In January, 1837, the political article is by Sir William Molesworth ("The Terms of Alliance between Radicals and Whigs"). Mill contributes only a short paper on an anonymous work of Arthur Helps, I believe his first publication—"Thoughts in the Cloister and the Crowd." This was another occasion when he displayed his passion for discerning and encouraging the first indications of talent and genius. I remember when I first came to London, this was one of the books he lent me; and we agreed that, in point of thinking power, Helps had not fulfilled the promise of that little work.

For April, 1837, he contributes a review of Fonblanque's "England under Seven Administrations," which would be easy work. The article is laudatory enough, but iterates the author's standing complaint against all the journals, namely, too great subserviency to the Ministry in power. The political summary in the number is again by Molesworth. Carlyle contributes a short paper on the "French Revolution," under an editorial *caveat*.

In July appears the review of Carlyle's "French Revolution," which Mill considers to have been one of his grand strokes in the "Review." Carlyle's reputation was as yet hanging very dubious. The effect to be produced by the "French Revolution" was extremely uncertain. Mill was now well acquainted with Carlyle, and knew how his peculiarities affected people, and how easily a prejudice might be created that would retard his fame for years. A judicious boldness was the only chance, and the article opens thus: "This is not so much a history, as an epic poem; and notwithstanding, or even in consequence of this, the truest of histories. It is the history of the French Revolution, and the poetry of it, both in one; and, on the whole, no work of greater genius, either historical or poetical, has been produced in this country for many years." Nothing could be better calculated to disarm prejudice against the book than the conduct of this article throughout; it is indeed a masterpiece of pleading, and deserved to be successful, as it was. A little later, Mill admitted into the "Review" an article on Carlyle by John Sterling, which was a still more complete exhibition of Carlyle, and is probably yet one of the best

criticisms that he has ever received. Still, when Carlyle, in his "Life of Sterling," refers to that article as the first marked recognition he had received in the press, he was unfairly oblivious to what Mill's article had previously done for him.

In this number the political article has to advert to the death of King William, and the events that followed. The Radicalism is as strong as ever; but the signature (E) is not Mill's, and I do not know the author.

The next number is October, 1837. The opening chapter is the political one, and is by Mill. Its text is the opening of the new Parliament of 1837. It is, if possible, more energetic and outspoken than ever. It addresses first the Ministers, and demands of them the ballot, as a special measure, and a number of other reforms, the Church included. It addresses the Radicals in Parliament in the usual strain. It hits the Tories very hard for their disingenuous dealing on the new Poor Law at the elections, and demonstrates that not they, but the Radicals, were the real upholders of the rights of property. The incitements to action are redoubled, as the power of the Liberals has diminished. I do not know of any compositions that better deserve to be compared with the Philippics of Demosthenes than Mill's political onslaughts in those years.

This number contained also the article on Armand Carrel. The best part of it is, perhaps, the history of French politics from the restoration of the Bourbons, on which he was thoroughly informed. The personality of Carrel is sketched chiefly from Carrel's biographers, to which he adds the impressions made by Carrel on himself. The distinguishing aim of Carrel's political life is remarkable for its common sense and intelligibility—to mitigate the mutual hostility of parties as a preparation for a constitutional *régime*. In the summing up of Carrel's personality Mill displays himself: "Like all persons of fine faculties, *he carried the faculties with him into the smallest things*; and did not disdain to excel, being qualified to do so, in those things which are great only to little men." This doctrine, I conceive, was held by Mill to an erroneous excess; the counter-doctrine of the limitation of the human faculties he never fully allowed for. He believed in *large* minds without any qualification, and saw very little incompatibility between the most opposite gifts.

In January, 1838, appeared the first "Canada and Lord Durham" article. In the "Autobiography" he celebrates the influence exerted by this and his subsequent article on the return of Lord Durham, and believes that they were a turning-point not merely in the settlement of Canada, but in the future of all our British colonies. Besides writing these articles, Mill exercised great personal influence on Lord Durham's Canadian measures, chiefly through his secretary, Charles Buller, who was always very open to Mill's suggestions. The present article apologizes for not reviewing the home political situation at large, be-

cause "a question has arisen which suspends all united action among Radicals. . . . On this most grievous subject we shall, in the course of this article, declare our whole opinion." He yet, however, finds it necessary first to denounce in fitting terms Lord John Russell's declaration of hostility to all reform on the first night of the session. The discussion of the Canadian problem is in his very best style, and is as well worth reading even now as any of his reprinted papers.

The number for April, this year, opens with one of his literary articles, reproduced in the "Dissertations"—"Alfred de Vigny." This article is his latest and most highly elaborated attempt to philosophize upon literature and poetry. The "Thoughts on Poetry" is his only other paper that he has thought worth preserving. The reviews of Tennyson and Carlyle's "French Revolution" are replete with just criticism, but do not reach the height of philosophical explanation. In his philosophy of style, there are many good points, but, as I conceive, some serious omissions. I doubt if he gave enough thought to the subject. The earlier part of the "De Vigny" article on the influence exerted on poetry by political changes, such as the French Revolution, is, I think, very happily expressed, and is quite equal to any other similar dissertations by our best historians and critics. It is when he comes to state the essential quality of the poetic genius or temperament that I think his view defective. In the first place, he puts too much stress on the emotional quality, and too little on the intellectual. In the second place, he is wrong in identifying the poet intellectually with the philosopher or thinker: he regards genius, whether in poetry or in philosophy, as the gift of seeing truths at a greater depth than the world can penetrate. On the former of these two heads he accepts De Vigny's emotional delineation—"the thrill from beauty, grandeur, and harmony, the infinite pity for mankind"—as the tests, or some of the tests, of the poetic nature; but he takes no direct notice of the genius of expression, the constructive or creative faculty, without which emotion will never make a poet, and with which the grandest poetry may be produced on a very slight emotional basis. To criticise Shelley without adducing his purely intellectual force, displayed in endless resources of language, is to place the superstructure of poetry on a false foundation. Shakespeare, in any view of him, was ten parts intellect for one of emotion; and his intellect did not, so far as I am aware, see truths at a greater depth than the world could penetrate. Mill inherited his father's disposition to think Shakespeare overrated; which, to say the least, was unfortunate when he came to theorize on poetry at large.

In August, appeared the review of Bentham, which I will advert to presently.

The next number is December, 1838. It closes with Mill's second article on Canada—"Lord Durham's Return"—vindicating his policy point by point, in a way that only Mill could have done. It concludes:

"If this be failure, failure is but the second degree of success; the first and highest degree may be yet to come."

The succeeding number appears in April, 1839, and contains the last, and in one view the greatest, of Mill's political series. Liberalism in Parliament is now at its lowest ebb: and only some new and grand expedient can be of any avail. Departing from his old vein of criticism of Whigs and Radicals, he plans the "reorganization of the Reform party" by an inquiry into the origin and foundations of the two great parties in the state. He inquires who, by position and circumstances, are *natural* Radicals, and who are natural Tories; who are interested in progress, and who in things as they are. I strongly recommend this article as a piece of admirable political philosophy, and I do not know any reason for his not preserving it, except that it is so closely connected with the passing politics of the time. At all events, it is the farewell to his ten years' political agitation. As this was the year of his second bad illness, I presume the article was written in the end of 1838, in the midst of great suffering.

After six months' interval, the next number appeared October, 1839. It contained no article of Mill's: he had been abroad the first half of the year. The number is otherwise notable for Sterling's article on Carlyle, and Robertson's on Cromwell. In March, 1840, was published the last number under Mill's proprietorship. It opened with his "Coleridge" article.

The Bentham article both stands alone as an appreciation of Bentham's work, and also forms one member of a correlative couple with the disquisition on Coleridge. No one possessed the qualifications of Mill for setting forth Bentham's merits and defects: we wish that he had made still more use of his means in depicting Bentham's personality. But in the mode of dealing with the defective side of Bentham, he undoubtedly gave offense to the Benthamite circle. He admits (in the "Autobiography") that it was too soon to bring forward the faults of Bentham; and, looking at the article now, we may be allowed to say that a little more explanation is wanted on various points; as, for example, Bentham's deficiency in imagination, his omission of high motives in his springs of action, and his aversion to the phrases "good and bad *taste*." It is apparent that Mill is criticising him from a point of view not taken by any other of Bentham's friends and disciples. When we turn to the "Coleridge" article, we find the more explicit statement of his position, as between the great rival schools. There we have a labored introduction to show the necessity of studying the conflicting modes of thought on all questions; we are told that, as partisans of any one side, we see only part of the truth, and must learn from our opponents the other part. Following out this text, Mill endeavors to assign the truth that there is in Conservatism, when purified by Coleridge and raised to a coherent system, or a philosophy. It is needless to advert to the detailed illustration, but the conclusion

is open to remark. A conservative philosophy may be, he says, an absurdity, but it is calculated to drive out still worse absurdities. To cut the matter short, he hopes from it, not the conversion of Conservatives into Liberals, but the adoption of "one liberal opinion after another as a part of Conservatism itself." Surely this is spreading the snare in the sight of the bird. We may ask whether, after forty years' trial, the Conservative philosophy of Coleridge has really borne such fruits ; or whether the adoption of Liberal opinions by Conservatives has had anything to do with philosophical consistency. Did Mr. Gladstone's conversion follow, in any degree, from Coleridge's philosophy?

Be this as it may, these two articles made a temporary alienation between Mill and his old associates, and planted in their minds a painful misgiving as to his adherence to their principles or to any principles. There is, in the "Logic," an extract from the "Coleridge" article, on the essential conditions of stability in any society. One of these conditions is, that there be something that is settled, and *not to be called in question.* Grote never ceased to convert this remark into an expression for the standing intolerance of society toward unpopular opinions.

From these two articles it is a natural transition to remark generally upon his principle in conducting the "Review" from first to last. He aimed at a wider comprehension than had ever been allowed before in any periodical representing a sect. He sought out fresh and vigorous thinking, and did not expect a literal adherence to his own opinions. The "Review" abounds in editorial *caveats*, attached to the articles. His principle of seeing partial truth in opposite sides was carried out in this form. He respected real ability when combined with sincerity ; and, as an editor, he never refused a reading to an offered contribution ; in fact, he delighted in the perusal of young authors' essays.

It was a noble experiment to endeavor to combine opposites and to maintain a perpetual attitude of sympathy with hostile opinions. A dissertation would be well expended in inquiring into its results. For the present, I remark that, as real opposition can not be smoothed down, we must still go on the old track of counter-argumentation ; while every honest truth-seeker endeavors to do justice to the case of an opponent. The watchword in these days of the "Review" was, "Sympathize in order to learn." That doctrine, preached by Goethe and echoed by Carlyle, was in everybody's mouth, and had its fling.

Mill's account of the management of the "Review," first as held by Molesworth, and afterward by himself, leaves uncertainties on various interesting points. He was at first sole editor, it appears, without being the avowed editor ; he does not say what this exactly meant. In point of fact, he rather supervised than edited the "Review." The

first acting editor, as I am informed, was Mr. Thomas Falconer, a barrister, and now a county court judge, Mill guiding him, but not being the active correspondent with contributors. During Mill's absence in the autumn of 1836, Mr. Falconer did all the editing uncontrolled, and, in the exercise of his editorial discretion, rejected Carlyle's article on Mirabeau, which Mill had previously approved of; the rejection was afterward reversed by Mill, who printed the article in the following January (1837). Although not the impression left by the narrative in the "Autobiography," I am constrained by the facts within my knowledge to believe that Robertson's period as assistant editor must have begun in the summer of 1837; and Molesworth's retirement could not have been till the end of the year. This affects our estimate of the numbers issued at Mill's sole risk. Molesworth may have borne the cost of ten or eleven numbers, which would leave Mill seven or eight, of the eighteen in all. Molesworth expended, no doubt, a considerable sum in starting it; and Mill must have been both very sanguine and also very much bent upon propagating his views in politics, philosophy, and literature, to take the whole risk upon himself. He paid his subeditor, and also sixteen pounds a sheet to the contributors that took payment. On these eight numbers he must have lost considerably. I can form some estimate of the loss from knowing what Hickson paid to contributors, when he took over the "Review," and worked it on the plan of making it pay its own expenses, he giving his labor gratis.*

* I was well acquainted with Mill's sub-editor, John Robertson, now dead. He was a fellow townsman, and was the medium of my introduction to Mill. I had, for several years, abundant opportunities of conversing with him, and learned a great deal about Mill during our intercourse. But he was very reticent about his own relations with Mill; he never told me, at least, what was his pecuniary allowance as sub-editor; nor did he explain how they worked together in the matter of editing: his habit was to style himself editor, and to seem to take the sole management. He has not left behind him any record of the connection between him and Mill; while I know enough of his history to make me doubt whether it commenced in 1836. Those that knew Robertson were not a little taken aback by Mill's character of him: "A young Scotchman, who had some ability and information, much industry, and an active, scheming head, full of devices for making the 'Review' more salable, etc." I remember on one occasion when Mr. Disraeli, in the House of Commons, quoted Mill as an authority on some economical view, Lord John Russell, in reply, spoke of him as a *learned author;* the next time I met him, he accosted me with his humorous twinkle, "You see what I am now, according to Lord John Russell." The *malapropos* here was not even so bad. Robertson's attainments were of the slenderest description, and his industry very fitful; but he could make a vigorous and brilliant display both in composition and in conversation. He contributed striking articles to the "Review," his best being his "Cromwell." He was also a very good writer of newspaper articles. His impetus and suggestiveness in conversation drew out Mill, who never talked better than he did with him. But although he made friends in London circles and in the clubs, he was very distasteful to many of Mill's associates, and increased the difficulties of carrying on the "Review"; being, in fact, for a *novus homo*, as Henry Mill styled him, somewhat arrogant. He took much interest in the Scotch Non-Intrusion controversy, and coached the Melbourne Government upon the question. About 1844 he disappeared from London, and was afterward rarely heard of. Mill scarcely ever mentioned his name in later years. His widow has gathered together the

Readers of the "Autobiography" remember the account Mill gives of his two most brilliant successes achieved by the "Review"—the saving of Lord Durham, and the rescuing of Carlyle's "French Revolution" from probable failure. In an interesting letter, written soon after the "Review" ceased, he insists with even greater *empressement* on these two feats, but adds, "My *third* success is that I have dinned into people's ears that Guizot is a great thinker and writer, till they are, though slowly, beginning to read him—which I do not believe they would be doing yet, in this country, but for me." His admiration of Guizot persisted some time longer, and led to his most elaborate article of all, in the "Edinburgh Review," five years later; which article he has seen fit to reprint; but we may suppose that Guizot's subsequent career and writings had a disenchanting effect on him as on many others.*

Reverting to the salient idea of his political articles for those seven or eight years—the fatality of there being no leader of the Radical party, although it was composed of very able men—I have often wondered in vain what he expected a leader to do or to be. Everything is not possible even to the greatest of chiefs; and it is doubtful whether any of the men that ever wielded the fierce democracy, from Demosthenes to Gambetta, would have headed a conquering majority in the last years of the Melbourne Ministry. He nearly admits as much, but not without reservation. He says explicitly that his father might have been such a leader; and even implies that he himself could have made the state of matters very different. We may well hesitate on both heads. That his father would have made an able minister or party leader, we must cheerfully allow; but his sentiments and views would have required a thick covering of disguise to allow even his being elected to Parliament, and still more to qualify him for meeting that most pressing want of the time—Reform of the Church.

This paper may fitly conclude with the remaining event of importance in the year 1840—the last illness and death of Mill's favorite brother Henry, which took place at Falmouth, on the 4th of April, in his nineteenth year. He was sent there in the beginning of the year, for the relief of his complaint—consumption; and John plied him with every kindness that he could devise. He went and lived at Falmouth, during his illness, as long as he could get away from his office; and had an opportunity at the same time of seeing a great deal of

extant indications of his career, but he left few or no reminiscences of his more interesting connections.

* I can not identify all the signatures of the articles in the "Review"; but, in addition to the contributors incidentally brought forward in the text, I may mention the names of Lytton Bulwer, Charles Buller, J. A. Roebuck, James Martineau, Harriet Martineau, Blanco White, Andrew Bisset, W. J. Fox, Mazzini, George Fletcher, Henry Cole. Never was so much "good blood" infused into a periodical of the same duration. Of old "Reviews," I think it would be difficult to produce nine volumes possessing the same amount of interest and stimulus.

Sterling, who was there also on account of chest-weakness. A letter of warm acknowledgment to Mr. Barclay Fox, of Falmouth, for the attention bestowed on Henry by his family, is for Mill unusually effusive, and teems with characteristic traits. One not a Christian, addressing a Christian family upon death, and wakening up the chords of our common humanity, is a spectacle worth observing.

A QUESTION OF EATING.

By WILLIAM BROWNING, Ph. B.

IT has long been considered, as by common consent a law of health, that all food should be eaten slowly, not swallowed until well masticated.

Some observations and experiments, however, have been recently made which indicate strongly that this principle of slow eating, so far as health is concerned, is not true with respect to all varieties of food.

Animals in a state of nature, as is generally recognized, tend to accommodate themselves in the most favorable manner to their conditions: if a cow naturally ruminates, why should a dog naturally take a chunk of meat at a swallow without stopping to chew it? It may be said that the ruminant has a special digestive apparatus, but the fact remains that the food is eaten as is best suited to it, and the dog, following nature, does what is best for him, or, in other words, if it disagreed with his digestion to eat rapidly, he would reform, and take it more slowly. Following out this idea, experiments were made upon a dog, with the following results: It the meat, before being fed to the dog, was reduced to a hash, or cut into fine pieces, the digestion was at best imperfect, a considerable portion of the undigested or imperfectly digested meat being found in the excreta. If, under the same conditions, meat was fed to the dog in large pieces, it was bolted at a gulp, with the result that little, if any, passed through undigested; compared with the result from the chopped meat, it could be called a perfect digestion for the coarse form, as compared with a decidedly imperfect digestion for the fine form. So far as simple experiment goes, this must be pretty conclusive for the dog; but can the same hold true with respect to the human subject?

A brief review of the first portion of the digestive process, so far as understood with regard to man, will help in answering this; and first to be considered is the mouth and chewing apparatus. Says Foster: "The chief purpose served by the saliva in digestion is to moisten the food, and so assist in mastication and deglutition. . . . In man, it has a specific solvent action on some of the food-stuffs. On fats it has only a slight emulsifying action, and on proteids none. Its character-

istic property is that of converting starch into grape-sugar."* According to Wundt, "the mouth secretions possess, besides mechanical, chiefly a chemical action—the changing over of the starch and glycogen contained in the food into sugar. The ferment body, which produces this transformation, ptyaline, is not a specific element of the mouth-secretion, since, aside from the intestinal secretions, all tissues and fluids of the body contain starch-ferment."†

From this it will be seen that no digestive action on meat or animal food takes place before reaching the stomach, and that, for vegetable food even, the action of the mouth-secretions is far from all-important.

As to the mechanical action of the mouth in preparing the food for deglutition, this is not specially necessary for morsels of meat of the ordinary size introduced into the mouth, while for a large portion of the vegetable or plant products eaten—and it is upon these that the saliva exerts its chemical action—mastication is necessary before they can be swallowed. The meat-foods are in themselves sufficiently moist, while many dried fruits, breads, and the like, in endless variety, first need thorough reduction.

A piece of jelly the size of a walnut would give little trouble in swallowing, since it is moist and of a yielding character, while few can swallow a pill the size of a pea without distress. Teeth and chewing, then, have their purpose, but, with the exception of the incisors occasionally, that purpose does not include meat unless it has become dried ; this is with respect to the food before it reaches the stomach, but, of course, the question then arises, Would it not be in a better condition for digestion if it had been thoroughly masticated?

The food on reaching the stomach is kept in rotary motion by the muscular walls, and only after a time does it begin to pass the pyloric orifice, and then only by degrees, since the digestion farther on is a much finer operation, and can go on but slowly. The length of time that the digestion properly takes, is, according to the present knowledge of the subject, several hours—in fact, somewhat longer than has generally been supposed. Now, if the meat is swallowed fine cut, it begins to pass through very quickly, and before it has been fully acted upon by the gastric juice. This action as regards meats consists in "dissolving the sarcolemma from the muscular fibers, and in dissolving proteid matters and converting them into peptones. . . . On starch, gastric juice has *per se* no effect whatever. . . . On grape-sugar and cane-sugar healthy gastric juice has no effect." In fats alone it has a slight emulsifying effect, but if still in the tissue it is dissolved out. Milk is accordingly acted on by being first curdled on reaching the stomach, after which it is leisurely dissolved again in the desired form.

The rotary movement of the contents of the stomach is to facilitate the action of the gastric juice—to bring the various particles and

* "Text-book of Philosophy," M. Foster, 1877.

† "Lehrbuch der Physiologie des Menschen," W. Wundt, vierte Auflage, 1878.

lumps of the entire mass into contact with it as it exudes from the stomach's walls. If the material has come from the mouth finely ground up, a considerable portion goes over into the duodenum before it has been properly acted upon; but, if it has come down in coarse lumps, these begin shortly to dissolve, passing into a more or less fluid condition, and this can be taken care of with about the same rapidity by the digestive apparatus following: by this arrangement no portion of the food would be allowed to pass from the stomach unprepared for the next step in the digestive process. All portions, then, even the finest fibers, of a meat diet, must be acted upon by the gastric juice before passing on; and this action progresses best by slowly wearing off the outside of the morsels.

Professor Ludwig has made some general experiments as to the truth of this theory upon himself, eating coarsely-cut meat at one time and fine at another, without at least being able to detect any ill effects whatever from morsels as large as it was convenient to swallow.* Many workingmen, business men, and others, almost bolt their food without loss of excellent digestion; we should bear in mind, of course, that they have to chew much of their vegetable food for convenience in swallowing, and also that the indigestion of business men occasionally is due more to their nervous condition at the time.

A slight amount of chewing or mumbling serves to detect harsh substances, as bones, and to prepare for swallowing; foreign matters of considerable size will, however, gradually make their way, and, if not rough, may pass without injury. The writer once had an experience of this nature with a piece of iron an inch in length and a third in diameter.

To conclude, then, with respect to man as well as other flesh-eaters: it is not only not necessary, but also not best, to chew meat of any kind to a fine condition, but to swallow it in convenient morsels; this militates against hash. With regard to all non-meat food, careful mastication is better, but hardly so necessary as has been supposed.

THE CONDITION OF WOMEN FROM A ZOÖLOGICAL POINT OF VIEW.

By W. K. BROOKS.

II.

TURNING now to another part of our subject, and bearing in mind the fact that by far the greater part of the external relations to which our actions are adjusted, and to which it is necessary that they should conform, in order to secure our preservation, safety, and wel-

* Lectures of Professor C. Ludwig (Leipsic), 1878–'79.

fare, are fixed and definite, and have been substantially unchanged for almost, if not quite, the whole period of human development, we see at once that, if the female mind is especially rich in the past experiences of the race, so far as these have resulted in laws of conduct, it follows that, since these experiences have been the same for all members of the race, there must be a greater uniformity in female character than in male character. As this statement is very abstract, I will try to put it in a less general form :

Experience of the order of events has shown that under certain circumstances, of frequent occurrence, certain conduct is proper and conducive to welfare, while its opposite is hurtful.

This experience being constantly repeated, the tendency to do the proper thing when the circumstances occur gradually takes the shape of an instinct, intuition, habit, or law of duty. Henceforward, all persons who have the impulse which has thus been formed will act in the same way when the circumstances arise, but two persons who have not the impulse will follow their individual judgments, and may or may not act alike.

As the female mind is characterized by the possession of these impulses, it is plain that it must be much more easy for one average woman to predict what another average woman will do, or feel, or think, or say in any given case, than for one average man to predict in the same way of another average man.

We may carry this line of thought a little further. Since male minds have the element of originality, male characters differ among themselves ; but, since all are members of the same species, fundamental similarity must underlie this individual diversity, and this fundamental similarity must subsist between female and male characters also. The average female character will therefore have more resemblance to two or more male characters than these latter will have to each other, and accordingly, in all cases where relationship or education has not led two men into the same way of looking at things, a woman will be better able than either of them to foresee the conduct of the other under given circumstances, and of course the advantage of a woman over a man in understanding the conduct of a woman will be still greater.

Since on the whole the differences between male characters are slight when compared with their resemblances, and since the points of resemblance are also points of resemblance to women, we should expect that, although the power of women to foresee male conduct is greater than the power of men to foresee female conduct, the superiority is not so marked as in the other three cases. This superiority of women in predicting conduct will be shown by their possession, to a much greater degree than men, of the power to influence or persuade as distinguished from the power to convince or move by arguments ; for to convince is to innovate and place matters in a new light, but the

secret of influence is a vivid appreciation of the established motives and incentives to conduct.

The relative power of persuasion of the two sexes, then, may be tabulated as follows:

The power of	To foresee the conduct of or to influence	Is greater than the power of	To foresee the conduct of or to influence
Women	Women	Men	Men
Women	Women	Men	Women
Women	Men	Men	Men
Women	Men	Men	Women

According to our hypothesis, the first line of the table should give the arrangement in which the difference is greatest. In the next line the difference is less; still less in the next; and least of all in the last case. In all cases, however, the superiority of women in this respect should be very marked.

Since our feelings are necessarily much more numerous than our judgments, we should expect to find it much more easy to persuade either a man or a woman than to convince; but, if our theory is correct, the advantage of influence over argument should be much greater when a woman is to be moved than when the effort is directed to a man.

Another difference between the sexes will at once be seen to follow from the above parallel. Since male character has the variable element, and may vary toward either good or bad, it follows that the ideally perfect male character will be more hard to define and more seldom realized than the ideal female character. It is difficult to prove such a statement as this, for the sentiments upon which individual opinion of the subject is based hardly admit of exact statement, but that there is an accepted standard of female excellence, and that the women who realize it are not rare exceptions, can, I think, be shown by the study of female character as depicted by dramatists, novelists, and poets. An appeal to this test is unfavorable to our hypothesis, for characters are selected for novels or poems on account of their originality; but I think that any one who will review Shakespeare, Thackeray, or George Eliot with the subject in mind, and who will compare the more important female characters, will find that they might be transposed from one novel or play to another with much less violence than would attend the transposition of the male characters.

It is hardly necessary to call attention to the obvious fact that our conclusions have a strong leaning to the conservative or old-fashioned view of the subject—to what many will call the "male" view of women. The positions which women already occupy in society and the duties which they perform are, in the main, what they should be if our view is correct; and any attempt to improve the condition of women by ignoring or obliterating the intellectual differences between them

and men must result in disaster to the race, and the obstruction of that progress and improvement which the history of the past shows to be in store for both men and women in the future. So far as human life in this world is concerned there can be no improvement which is not accomplished in accordance with the laws of nature; and, if it is a natural law that the parts which the sexes perform in the natural evolution of the race are complemental to each other, we can not hope to accomplish anything by working in opposition to the natural method. We may, however, do much to hasten advancement by recognizing and working in accordance with this method.

It is no more than just, too, to point out that the peculiar bodily organization and physiological functions of woman have nothing to do with our conclusion. If the perpetuation of the human race were as simple as that of the starfish, where the demands made upon the female organism during reproduction are no greater than those made upon the male, the mind of woman would still be the organ of intellectual heredity, and the mind of man the organ of intellectual variation.

Up to this point I have simply indicated some of the differences between the sexes which the study of the evolution of organisms would lead us to expect. I shall now quote a few extracts from authors whose writings upon the position of women are accepted as valuable contributions to our knowledge of the subject, in order to show that they have recognized the existence of the very differences which we have been led, by theoretical reasoning, to expect.

Mill's essay on "The Subjection of Woman" must be regarded as the most important contribution to the discussion of the relative positions of the sexes as related to future progress; and it is interesting to note that, while he holds that the existing differences are not natural, but are due to the subjection of one sex by the other, he fully recognizes certain profound and characteristic differences, which are precisely in accordance with the present view of their origin and purpose. Mill's evidence as to important differences between the sexes is of the greatest value, both on account of the weight of his opinion in itself, and on account of his being in this case an unwilling witness. He says: "Looking at women as they are known in experience, it may be said of them, with more truth than belongs to most generalizations on the subject, that the general bent of their talents is toward the practical. This statement is conformable to all the public history of women in the present and in the past. It is no less borne out by common and daily experience. Let us consider the special nature of the mental capacities most characteristic of a woman of talent. They are all of a kind which fits them for practice, and makes them tend toward it. What is meant by a woman's capacity of intuitive perception? It means a rapid and correct insight into present facts. It has nothing to do with general principles. Nobody ever perceived a scientific law of

nature by intuition, or arrived at a general rule of duty or prudence by it. These are results of slow and careful collection and comparison of experience; and neither the men nor the women of intuition usually shine in this department, unless, indeed, the experience is such as they can acquire by themselves. . . . To discover general principles belongs to the speculative faculty; to discern and discriminate the particular cases in which they are or are not applicable constitute practical talent; and for this women, as they now are, have a peculiar aptitude." It is only necessary to change two or three words in this last sentence in order to show its complete agreement with the demands of our theory. Its meaning will not be altered by the following reading, which serves to bring out more clearly its implications: To discover general principles belongs to the progressive aspect of the mind, which is most strongly developed in men; to preserve and apply the general principles which are already established belong to the conservative side of the mind, and for this women, as they have been made by the evolution of the race, have and should have a peculiar aptitude. Mill continues as follows: "I admit that there can be no good practice without principles, and that the predominant place which quickness of observation holds among a woman's faculties makes her particularly apt to build over-hasty generalizations upon her own observation, though at the same time no less ready in rectifying these generalizations as her observation takes a wider range. But the corrective to this defect is access to the experience of the human race; general knowledge—exactly the thing which education can best supply."

This sentence, when viewed in connection with our present theory of the relations of the sexes, gives the key to the question of female education—for that form of education which supplies the general knowledge which is so important for the correct application of principles to special cases is culture, as distinguished from the technical training which looks to the discovery of new laws.

The next passage which I shall quote is of the greatest importance, for, founded as Mill's autobiography and numerous passages in his various works tell us it is, upon the personal experience of his life, it contains the germ of the idea which, if fully investigated, might have led him to entirely remodel his essay upon women; the idea that the sexes do not naturally stand in the relation of superior and inferior, nor in that of independent equals, but are the complemental parts of a compound whole. He says: "This gravitation of women's minds to the present, to the real, to actual fact, while in its exclusiveness it is a source of errors, is also a most useful counteractive of the contrary error. The principal and most characteristic aberration of speculative minds, as such, consists precisely in the deficiency of this lively perception and ever-present sense of objective fact. . . . Hardly anything can be of greater value to a man of theory and speculation, who employs himself, not in collecting materials of knowledge by observation,

but in working them up by processes of thought into comprehensive truths of science and laws of conduct, than to carry on his speculations in the companionship, and under the criticism, of a really superior woman. There is nothing comparable to it for keeping his thoughts within the limits of real things, and the actual facts of nature. Women's thoughts are thus as useful in giving reality to those of thinking men as men's thoughts in giving width and largeness to those of women." Here we have a clear recognition of the law that width and largeness, mental growth, originate in the male, and are then preserved by women, and the context leaves no room to doubt that the "really superior woman" which filled the author's memory at the time this passage was written, was a woman in whom this feminine characteristic was well developed; that she was a woman filled with the fruits of human experience; and it is a little strange that he fails to see that the relation with which, for a man of speculation, there is nothing comparable, may have a wider value, and be of the greatest importance to humanity as a whole.

The next passage which I shall quote is still more to the point. He says: "Let us now consider another of the admitted superiorities of clever women, greater quickness of apprehension. Is this not preeminently a quality which fits a person for practice? In action everything depends upon deciding promptly. In speculation nothing does. A mere thinker can wait, can take time to consider, can collect additional evidence; he is not obliged to complete his philosophy at once lest the opportunity should go by. The power of drawing the best conclusion possible from insufficient data is not, indeed, useless in philosophy; the construction of a provisional hypothesis consistent with all known facts is often the needful basis for further inquiry. But this faculty is rather serviceable in philosophy than the main qualification for it; and for the auxiliary as well as for the main question the philosopher can allow himself any time he pleases. He is in no need of doing rapidly what he does; what he rather needs is patience to work on slowly until imperfect lights have become perfect, and a conjecture has ripened into a theorem. For those, on the contrary, whose business is with the fugitive and perishable—with individual facts, not kinds of facts—rapidity of thought is a qualification next only in importance to the power of thought itself. He who has not his faculties under immediate command in the contingencies of action might as well not have them at all. He may be fit to criticise, but he is not fit to act. Now it is in this that women, and the men who are most like women, confessedly excel. The other sort of man, however preëminent may be his faculties, arrives slowly at complete command of them; rapidity of judgment and promptitude of judicious action, even in the things he knows best, are the gradual and late result of strenuous effort grown into habit."

I have quoted these passages from Mill at length, as they give a

very clear although somewhat narrow statement, by the strongest advocate of the fundamental likeness of the sexes, of what I take to be the most important psychological difference between them.

According to Mill—and I think that universal experience will justify his view—the highest type of woman is distinguished by her power of intuition, by her concrete acquaintance with the laws and principles which have been established by experience and generalization, by a constitutional knowledge of these laws which amounts to habit, so that she is able to recognize in actual practical life the action which is proper in any given case, without the necessity for a slow process of comparison and thought; by that immediate command of the faculties which is necessary for action.

This power of correctly and promptly applying the established scientific laws, which are the result of all the experience of the past, to the actions of ordinary practical life, is common sense, as distinguished from originality.

The highest type of male intelligence, on the other hand, is distinguished by the power to abstract and compare, and by a slow process of thought to reach new generalizations and laws, and to see these in their abstract and ideal form, freed from all the complications of their concrete manifestations. To this power is often joined a woful and disastrous lack of common sense, or power of prompt and proper decision and action in special cases.

Lecky, in his "History of European Morals," gives an excellent summary of the most marked differences between the male mind and the female; and, although we do not agree with him in thinking that a departure from the male type is in all cases to be regarded as an inferiority, we can not fail to note how exactly his account agrees with the demands of our hypothesis.

He says: "Intellectually a certain inferiority of the female sex can hardly be denied when we remember how almost exclusively the foremost places in every department of science, literature, and art have been occupied by men; how infinitesimally small is the number of women who have shown in any form the very highest order of genius; how many of the greatest men have achieved their greatness in defiance of the most adverse circumstances, and how completely women have failed in obtaining the first position, even in music and painting, for the cultivation of which their circumstances would appear most propitious. It is as impossible to find a female Raphael or a female Händel as a female Shakespeare or a female Newton. Women are intellectually more desultory and volatile than men; they are more occupied with practical instances than with general principles; they judge rather by intuitive perception than by deliberate reasoning or past experience. They are, however, usually superior to men in nimbleness and rapidity of thought, and in the gift of tact, the power of seizing rapidly and faithfully the finer impulses of feeling, and they have therefore often

attained very great eminence as conversationalists, as actresses, and as novelists. In the ethics of intellect they are decidedly inferior. Women very rarely love truth, though they love passionately what they call 'the truth,' or opinions they have received from others. They are little capable of impartiality or of doubt; their thinking is chiefly a mode of feeling; though very generous in their acts they are rarely generous in their opinions, and their leaning is naturally to the side of restriction. They persuade rather than convince, and value belief rather as a source of consolation than as a faithful expression of the reality of things. They are less capable than men of distinguishing the personal character of an opponent from the opinions he maintains. Their affections are concentrated rather on leaders than on causes, and if they care for a great cause it is generally because it is represented by a great man, or connected with some one whom they love. In politics their enthusiasm is more naturally loyalty than patriotism. In benevolence they excel in charity rather than in philanthropy." While I can not believe that Lecky's statement is entirely unprejudiced, I think no one will deny that the views which I have quoted agree in the main with those which have gained general acceptance in the past. At the present time, however, there is a growing tendency to regard the relations of the sexes as due in great part to male selfishness; and while the substantial correctness of our view of the differences between the male and the female character is acknowledged, its origin is attributed to the "subjection" of women by men. In this paper I have attempted to present reasons, which I believe are new, for regarding the differences as natural and of the greatest importance to the race.

Those who acknowledge the weight of my argument, as applied to evolution in the past, may, however, question its applicability to the human evolution of the future. It may fairly be urged that while we grant that the course of evolution from the lower forms of life up to rational man has been by the slow process of variation and heredity, we have now passed into a new order of things, and the great advances of the human race have been and are now brought about by the much more rapid and totally dissimilar process of intelligent education. It may be urged that heredity does very little more for the civilized than for the savage child, and that the wide difference between the savage and the civilized adult is mainly the result of the training and instruction of the individual; that it has not been brought about by the destruction of those children whose congenital share in the results of the intellectual advancement of the race is most scanty. It may be urged that, since man has reached a point where progress is almost entirely intellectual, and depends upon his own efforts, he is free from the laws by which development up to that point was reached.

We are not concerned at present with the question how far progress might be accelerated by intelligent selection, and we may therefore conditionally accept the view that future progress, for some time

to come at any rate, must depend almost entirely upon education ; but, far from holding that this conclusion will allow us to ignore or obliterate the differences between the male and the female intellect, I believe that the full significance of these differences can be appreciated only in their relation to higher education. The scope of the present paper will only allow the space for an outline sketch of the reasons for this belief. As the field of human knowledge widens in all directions, as society becomes more complex, and as the points of contact between man and his inorganic environment multiply, the amount of general education which each individual must receive before he is in a position to hold his own, and to guide himself rationally in all the emergencies of life, and to enjoy his share of the benefits which our intellectual advancement has placed within his reach, increases in a geometrical progression, and the amount of time demanded for general liberal education increases in the same ratio. Meanwhile the amount of special preliminary training which must be undergone in order to fit a person for new and original work in any department of knowledge or art increases at the same rate, and makes greater and greater inroads upon the time which is needed for general education. At present the most important, delicate, and complicated of educational problems, the problem which each individual must meet and decide upon, and the problem which engrosses most of the thought of educational bodies, is where to draw the line between general culture and practical or technical training.

Culture in its widest sense is, I take it, thorough acquaintance with all the old and new results of intellectual activity in all departments of knowledge, so far as they conduce to welfare, to correct living, and to rational conduct ; that is, culture is to the intellectual man what heredity has been to the physical man. Culture is concerned only with results, not with demonstrations, and does not look to new advances ; while technical training is concerned with methods and proofs, and values the results of the methods and investigations of the past only as they contribute to new advances. Technical training looks to progress in some one definite line, one radius of the growing circle of the domain of human intelligence, and ignores the rest of the circumference. It is to the intellectual man what variation is to the physical man. By culture we hold our own, and by technical training we advance to higher levels. Both are equally important to human welfare, and the great problem of the future is how to secure each to the greatest degree without sacrificing the other. The analogy of the rest of the organic world would seem to indicate that this is to be accomplished by "division of labor." If the female mind has gained during its evolution an especial aptness for acquiring and applying the results of past progress, by an empirical method and without the necessity for studying proofs and reasons, it would seem especially fitted for culture, as distinct from training, while the

male mind is best fitted for education by that process of inductive training by demonstration and experiment which leads to new advances. The methods employed in the general instruction of young men and young women should not therefore be identical. With the one the field may be very wide and the methods empirical, and with the other the range more narrow and the methods more strictly logical. In this way each type of mind will be developed in the manner for which it has an especial fitness; and we have the strongest grounds for the belief that this method would also gradually result in the extension of that congenital acquaintance with nature which is the common stock of the race, and would thus leave more time for the special training of those minds which are by nature best fitted to receive it. It is unavoidable that a bald outline of a view which has such wide implications should afford many openings for serious criticism; but the present article does not admit of the expansion of the idea, even if its detailed examination could be fairly included in the province of biology. Having traced the origin and significance of sex from its lowest manifestations to a point where it becomes purely intellectual, the biologist may fairly leave the subject in the hands of the psychologist.

A VISIT TO THE NEW ZEALAND GEYSERS.

By CLEMENT BUNBURY.

THE Geyser district of New Zealand is, at some future day, to be the great sanatorium of the southern world; meanwhile, it is so little known that some account of a visit lately made to it may not be uninteresting.

While "globe-trotting" with a friend, we found ourselves in April last year at Auckland, New Zealand, and were kindly invited by the Governor to join him in a visit he was going to make, with the Commodore and a large party, to the geysers.

The party assembled at Tauranga, a port about a hundred and forty miles southeast of Auckland, and the most convenient starting-point for Ohinemutu, the headquarters of the hot-lake country. The little town was gay with flags and triumphal arches, and crowded with Maories looking forward to a big drink in return for the dance with which they received the Governor. I was disappointed to find the natives were broad-nosed, thick-lipped, tattooed savages, or at least so they appeared at first sight. The men are decidedly superior in appearance to the women, and among the young people tattooing is becoming unfashionable.

From Tauranga to Ohinemutu is about forty miles over a good road, except through what is called "the eighteen-mile bush," where

the road possesses all the ills to which a bush-road is heir. About three miles from Tauranga the road passes through the celebrated Gate Pah, where English soldiers in a panic ran away from the Maories, and left their officers to be killed. The Pah is well placed on the top of a ridge looking out over Tauranga and the sea. Almost all traces of the earthworks have now disappeared, and the cluster of gravestones in the neglected little cemetery at Tauranga will soon be the only remaining evidence of that disastrous day. About eight miles beyond the Pah we had our first experience of a New Zealand bush. It was magnificent. I can not say the same of the road. A great part of it is what is called "corduroy road," that is, trunks of trees, about eight or nine inches in diameter, were laid close together across the track, forming a kind of loose bridge over the soft places. Some of the trees, especially the rimu, a species of yew, here called a pine, were of immense size and age; in places tangled masses of red flowering creepers completely hid the trees. The tree ferns were the perfection of lightness and beauty, the dark-leaved shrubs setting them off to great advantage.

At Ohinemutu we found two small hotels; the charges were very moderate, and the attention paid to visitors is all that can be desired. The land here still belongs to the Maories, who refuse either to sell it or let it; and the hotel-keepers, who are only tenants-at-will, are naturally unwilling to spend much money in building with such an insecure tenure. One creek of Lake Rotorua, on the banks of which Ohinemutu stands, is filled with boiling springs, which heat the waters of the lake for a considerable distance. This creek is a favorite bathing-place, but, as it is dangerous in the dark, my friend and I tried a natural bath, which has been inclosed by the hotel-keeper to keep out the natives. It was as hot as we could bear it, very soft, buoyant, and bubbling, and after our long, bumpy drive, perfectly delicious. When we had got thoroughly warmed through, I thought lying in the soft bubbling water the most perfect sensuous pleasure I ever experienced.

The next morning we visited the many boiling-water and mud springs in the immediate neighborhood of the village. On a small peninsula, between our hotel and the lake, there are a great many native dwellings, called *whares* (pronounced *warries*). A whole tribe formerly lived there, but one night the end of the peninsula suddenly collapsed and disappeared in the lake, destroying, of course, all its inhabitants. There is, in the midst of the village, a large native building called the "Carved House"; its sides are covered, inside and out, with intricate carving, chiefly of grotesque human figures. By Maori law, the carved figures may only have three fingers on each hand, lest any evil-disposed persons should mistake them for caricatures of their ancestors. This native settlement owes its existence to the many hot springs with which the peninsula abounds, the boiling water standing

to the natives in the place of fire, and saving them an infinity of trouble with their cooking and washing arrangements. One desirable result of the abundance of warm baths is the undoubted cleanliness of the people.

About a mile farther along the banks of the lake, we came to what is called the Sulphur Point. It certainly deserved its name. The surface of the ground is literally honeycombed with pools of boiling water and mud-holes, impregnated with sulphur or alum. The smell was perfectly fearful. One mud-bath that we ventured into certainly did not look tempting; great waves of thick brown mud bubbled up in the middle of the pool, and rolled lazily toward its sides. It was just a pleasant temperature, very smooth and oily, and, notwithstanding its appearance, decidedly a success. We next tried a pool of thinner mud, and ended with a swim in the cold waters of the lake, feeling all the better for our strange experience. All the pools have been given stupid English names by the hotel-keeper; the one we first bathed in is known as "Painkiller," and enjoys a high reputation for curing rheumatism. It was here that a young Englishman lately nearly lost his life. A large bubble burst near his face, the poisonous gases from which rendered him insensible; and had it not been for a Maori, who happened to be standing near, he must infallibly have been drowned. The whole neighborhood is a dangerous one; the crust of the earth is in many places so thin that one may at any moment find one's self standing in boiling water. The guides take so much pleasure in recounting all the accidents that have happened, that I felt I should be conferring a personal favor on them if I fell in, and was boiled sufficiently to be worth talking about in the future. The surface of the ground is in places covered with masses of pure sulphur. We lighted it in places, and it began to burn freely, and may be burning still for all I know to the contrary.

In the afternoon we saw, for the first time, a body of water thrown any considerable height into the air. It was at a place called Whakarewa-rewa, about two miles from the hotel, amid the finest hot springs of the Rotorua district. The geyser had been dormant since 1869 until this particular week, and each day it seemed to gather strength and volume. The mighty fountain has formed for itself a fine circular base, about thirty feet high, of silica, roughly resembling white marble. After being quiescent for a few minutes, the water began to leap up through the circular cavity at the top of the cone, and, rising higher and higher at each leap, at last culminated in splendid volumes of clear bright boiling water, thrown fully forty feet into the air. Dense masses of steam floated from the water in mid-air, but the column of water itself fell so nearly perpendicularly that we were able to stand as near to it as the intense heat would permit. After playing for about five minutes, the fountain gradually subsided, to take a rest, lasting about eleven minutes, before its next display. The geysers

are curiously intermittent in character, and according to all accounts are, on the whole, less active than formerly.

Two of the baths here deserve mention. One called the oil-bath has water so oily as hardly to adhere to the skin enough to make a towel necessary on coming out; the other is a very warm creek opening out into a fast-flowing river of cold water, and affording the most delightful gradations of temperature between the two. All the pools have their distinctive character: some are very active, others sullen; some pretty, bubbling, shallow basins, others dark deep blue of endless depth; some bright and clear as crystal, others milky, or of mud of various consistency; some blowing off steam like fifty steam-engines, and many, alas! very many, smelling beyond the power of words to describe. It is curious how quickly one gets accustomed to the ceaseless sound of boiling water, or the dull, soughing sound of boiling mud that one hears on all sides, often without being able to see the hole whence it comes.

In the evening the natives treated us to a *haka*, or dance, in honor of the Governor. It took place in the carved house I have already spoken of, the weird, grotesque carvings of which added to the strangeness of the scene. There were about a hundred dancers ranged in five rows, the front one consisting of about twenty young women gorgeously apparelled in tight-fitting red or white calico bodices, and flaming-colored rugs worn like kilts. When the Governor entered they greeted him with the most awful noise, shouting, yelling, laughing, and in some diabolical way imitating the noise of the beating of tin cans, the barking of dogs, and rapid hand-clapping. From one or two of the specimens that were translated to us, it was as well, perhaps, that their shouts of welcome were expressed in Maori language. The young women certainly seemed to enjoy, and to make the most of, the opportunity for saying naughty things. The dance lasted about an hour; it was curious, and as a novelty amusing, but rather monotonous. There was but little movement of their feet; it consisted chiefly of swaying their bodies and arms about, going down on their knees, imitating rowing and gathering crops, slapping their own legs and then their neighbors'. The men then took the place of the women, and went through very similar performances. The whole dance was accompanied by a noise that would have put pandemonium to shame; it sounded like a mixture of beating of trays, dogs fighting, gigantic snoring, and a very full, deep bass rumbling in the throat. At times there seemed to be a kind of rhythmic song, interspersed with yells and short, sharp cries of "Hue, hue!" "Ha, ha!" "Pakeka!" The young women winked and grinned and twisted about beyond what was strictly correct; but they seemed to enjoy the really hard work of the dance most thoroughly. There was always a chief running up and down, dancing, and declaiming in the foreground, bidding defiance to all the world apparently, but in reality, I believe,

merely suggesting that he would like to drink his Excellency's health. Far the most comical feature of the dance was a naked little imp who stood in front of the first row, exactly opposite the Governor, and imitated playing the fiddle with his little thin arms, all the while thrusting out his tongue, rolling his eyes nearly out of his head, and making the most fearful faces and contortions. A little girl who tried to do the same had not nearly the same real genius for making herself hideous and grotesque. At last a liberal supply of beer was promised them; the dance came to an end, and the Governor departed amid an uproar if possible more awful than before. The natives were very well-grown, friendly, and cheery, with a perfectly childish delight in making a noise. Their noses are too wide and their mouths too big for them to be good-looking; but, with large bright eyes and white teeth, many of them are very pleasant-looking.

Later in the evening two chiefs of another tribe sought an interview with the Governor to invite him to visit Wairoa, the village nearest to Rotomahana, the gem of the hot-lake country. They were very jealous that he should visit Rotorua and not pay them a visit. I never knew two men less willing to take "No" for an answer, or much readier in meeting all objections; but the Governor was obdurate, and they had to be content with the Commodore, whom they called "the king of the sea," and apparently regarded as very small beer compared to "the king of the land." One of the chiefs was called Major Kemp, having been given the title for services rendered to us during the last Maori war. He was an intelligent, courteous man, of splendid *physique*, certainly over six feet high, and strong and active as a tiger.

Next morning we rode over to Major Kemp's village of Wairoa with the Commodore, Mr. F—— (the member of the Ministry in attendance on the Governor), and Captain Mair, the resident magistrate, who, from his knowledge of the country and language, proved himself an invaluable cicerone. On our way we passed through a lovely piece of bush, in which we found a specimen of the curious natural phenomenon "the vegetable caterpillar." It appears that the caterpillar, when it buries itself in the ground preparatory to changing into a chrysalis, is attacked by a fungus, which kills it, and sends out one or two shoots, something like the seed-bearing fronds of some ferns, several inches in length, from the head of the unfortunate caterpillar. Farther south we came across a tract of bush where they are by no means uncommon. The caterpillar is a large one, and, as far as I could judge, of the goat-moth species. At Wairoa we presented some gaudy-colored rugs to Major Kemp's wife and one or two other important ladies. They gathered together by the roadside trying on their new things, inside and out, and seeming immensely pleased with their finery. We visited a pretty waterfall and cascade, and then embarked in a boat, rowed by four stout young Maories, to cross Lake Tarawera. The lake is very beautiful; the shores are well wooded, in many places

coming sheer down steep and rocky several hundred feet into the water, and backed by fine mountains. At the end of the lake a stream of warm water runs into it from the Lake Rotomahana, but the stream is so swift that progress against it is very slow; we therefore left the natives to bring the boat up, while we walked on with one of them for a guide. A walk of about a mile brought us to the top of some high ground, whence we got our first view of the glorious white terrace of Rotomahana.

It was a sight that never can be forgotten. It is impossible to imagine anything more lovely than the appearance of that marvelous marble-looking terrace, lying, set in a green frame, on the mountain-side, and reflected again in the glassy water of the lake, as we first saw it in the rosy light of a calm autumn sunset. To get to the terrace we had to cross the warm stream; the boat had not yet appeared, and we were impatient. After a slight hesitation, the guide thought he could carry us across. The stream was deep and swift, but the man took us all safely over without a single false step; only when it came to Mr. F——'s turn, the Maori wanted to have a little preliminary practice with him on dry land first, Mr. F—— being about three times as big as his porter. Captain Mair then took us under his charge to explore the wonders of the white terrace.

The general appearance of the terrace is that of a gigantic staircase on the mountain-side. It is about one hundred and fifty feet in height, and at the top nearly three hundred feet across, and fully twice as much round the lowest steps. The steps are roughly semicircular in form, varying from two or three to ten feet in height, more or less smooth on their horizontal, but on their perpendicular faces carved by the trickling water into the most delicate representations of flower and fruit carvings, or soft, white, coral sprays. At the top there is an immense caldron of pale-blue boiling water of unknown depth; even the steam rising from it in clouds was quite decidedly blue. This caldron in all probability is the crater of an extinct volcano which has been invaded by water. The idea that the origin of the terrace is due to volcanic agency, and not to deposits by the water, is supported by the fact that where the silica crust has been knocked away a formation of coarse tufa and pumice-stone appears. The depositing power of the water is, however, very great, and articles exposed for curiosity to its action become very quickly covered with a delicate white coating. On each step there are holes of various sizes filled with the most lovely blue water, slightly milky, of the most perfect turquoise-blue, looking, oh! so beautiful in its coral cups. The water from the caldron pours down, steaming and bubbling, overflowing from hole to hole, losing its heat by degrees on the way, until it reaches the lowest steps quite cold. These lowest steps were especially beautiful; the pools on them were larger and bluer than on the others, and the absence of steam left them in perfect peaceful beauty; the steps, too, though generally of a purer

white than the upper ones, had in places large black markings on them that brought out to great advantage the contrast between their delicate pale-blue water and that of the dark-colored lake that lay at their feet.

We camped for the night close by the terrace, cooking all our provisions in one of the natural boiling springs. During the night an ill-natured rat jumped into our spring, and compelled us to seek another cooking-place for breakfast. While the Commodore and I were lying in a warm pool, smoking a last cigar before going to bed, Mr. F—— proposed to join us; we warned him that the pool was very shallow, but he was not to be dissuaded. When the moon shone out from behind a cloud it revealed, as we expected, a round white island in the middle of our bath. After trying in vain to make waves big enough to cover our newly-discovered island, we induced Mr. F—— to roll over; the result was very comical, but it could hardly be said to be an improvement. We found it no easy matter to get to sleep; the ground was very hot, and every now and then jets of hot steam would find their way through the thin earth-crust and parboil us and soak our blankets. All night there was the sound in our ears of boiling water, so that it was difficult to get rid of a feeling of insecurity natural to so uncanny a sleeping-place.

We began the next day with an early bath in the basins on the white terrace, beginning with the hottest we could bear, and working our way down to the cold water: mortal man surely never had a more magnificent bath-room. After breakfast we crossed the lake in canoes to the pink terrace. It is not so large as the white, but of smoother and more regular form; none of the steps are more than six feet high, so that the baths in them are all shallow, but the steps, covered with a bright salmon-pink incrustation, run more evenly right across the terrace. Some of our party, who had visited the terrace two days before, had, I am sorry to say, written their names in pencil on the smooth pink steps. The warm water, instead of washing them away, had even in so short a time covered them with a transparent film of silica, and there they will remain, along with the names of hundreds of other cockney-souled tourists, enshrined for ever. The water here is perfectly clear, and of a much deeper blue than at the other terrace; that at the top is of a splendid bright deep blue, but the steam is very white. The setting of the two terraces is quite different; the white one lies against a hill of moderate height and gentle slope, appearing from its countless jets of steam to be a hill of fire. The pink one lies against a fine bold hill some two thousand feet high, from which it runs like a steep staircase directly into the lake. They are rival beauties, both deserving many worshipers—the white one, I believe, having the most.

Some of the small mud geysers behind the white terrace were curious; they were growling, and throwing mud of every variety of color

about. One of pale gray mud was said to be eaten by the Maories as medicine; it had a decidedly acid taste. One big hole was blowing off immense volumes of steam with the noise of a dozen steam-engines shrieking in friendly rivalry. A little farther on was a pool of cold vivid green water—greener far than the leaves of the shrubs near it, and strongly charged with sulphuric acid and iron. The wonders of Rotomahana really seemed endless, but, alas! it was Saturday afternoon, and we had to get back to Ohinemutu that night, and, however unwillingly, we were obliged to bid the place farewell.

Strolling about after our evening bath on Sunday, we came across a pool in which there were two Maori young women bathing. When we found they had their pipes with them we sent to the hotel for some beer, and sat down to have a chat with them, and found one of them understood a little English. They said they had been in the water an hour before we came. I wonder they were not boiled, the water was very hot and nasty, and we kept them in at least another hour. This was, I think, the pool which Mr. Trollope speaks of having found himself bathing in with three young women; if so, it has now deteriorated very much, and nothing would have tempted us to venture into its dirty waters.

On Monday we rowed over Lake Rotorua to an island called Mokoia. Sir George Grey told me that at one time he lived on the island; it is, in consequence, still rich in fruit-trees and cultivated ground. A legend of this island reminds one of the story of "Hero and Leander." Hinnemoa, a maiden living on the mainland, one day, on hearing the flute of her lover, Tutanekai, the chief of the island tribe, jumped boldly into the lake and swam across the intervening five miles in safety. Tutanekai scarcely deserved his good fortune, he having a few days before made an attack on the mainlanders and destroyed all their boats. On the highest peak of the island I found myself in a small native burying-ground; it was surrounded by a deep ditch and bank. There were some forty or fifty graves, each marked by a small headstone, but I had not much time to examine them closely, having a proper fear of the unknown penalties incurred by the violation of anything *tapu* or sacred. On our way home, Captain Mair showed us his beautiful collection of native weapons, carved boxes, and wonderful cloaks made of native flax, and feathers, most of them presents from grateful natives, or, as we enviously suggested, bribes.

My friend and I, after saying good-by to the others, started the next morning with the guide Fraser to visit the more southern limits of the hot-spring country. A ride of about thirty-five miles brought us to the Waikato, a large swift-flowing river, the scene of much bloodshed during the war. The canoe that we had expected to cross in was not forthcoming, so that we had to camp where we were; luckily the night was fine, and we had plenty of provisions. We had a fine lunar display: round the moon, for a breadth of about twice its own ap-

parent diameter, there was a ring of bright white light; then came a ring of light brown, deepening outward to purple; then came blue growing into green, that melting into yellow, that deepening through orange into a beautiful red. The series of rings was very perfect, about sixteen times the width of the moon, and lasted, apparently without any change, for several hours.

After crossing the river at daybreak we soon came to a native settlement of Orakei-korako, and there got a native to guide us to the alum cave, for which the place is famous. The entrance to the cave is completely hidden by creepers and magnificent tree-ferns with heavily silvered fronds fully twelve feet in length. Descending the cave some eighty or ninety feet by almost regularly formed steep steps, we found a beautiful pool of clear blue water at the bottom. Of course we bathed in the pool; it was warm, strongly impregnated with alum, and when we were swimming with our backs to the entrance it had, curiously enough, exactly the appearance of getting its light from below. The Maori name for it is "the looking-glass," so called, probably, from its power of reflecting light. The floor and walls of the cave were thickly covered with deposits of pure alum, and the roof was colored in parts with pretty variegated patches resembling marble frescoes.

Soon after leaving the cave my horse broke down, and it was with the greatest difficulty that I got him to the high-road before he succumbed entirely. While waiting to see if he would recover I saw three people riding toward me: one was a smart-looking native in the uniform of the armed constabulary, the second was a lady, and, to my surprise, she too was a native. She wore a tall black hat and dark veil, a dark-blue well-fitting riding habit, a dainty pink-and-white necktie; I afterward saw she wore a pair of French-looking boots, and black-and-white stockings. She was, in fact, a "real dark swell." She talked a little English, and, after hearing of my plight, she made the third rider, an ordinary-looking native, dismount, and give me his horse, he remaining to do what he could for mine. We rode on to a native village, and there had some boiled potatoes and dried peaches for lunch. My fair riding companion soon afterward appeared without the riding habit, but with a dirty clay pipe in her mouth; I fear her civilization, like her dress, was only a new habit, whose greatest charm was the ease with which it could be discarded. I had eventually to walk to Taupo, a township on the biggest lake in the country, where we intended staying a few days.

Major Roberts, the head of the constabulary, who had been asked to help us, kindly provided us with horses, and an orderly as a guide. We first visited the falls of the Waikato; the great broad river is contracted into a narrow channel, not more than thirty feet wide, with precipitous banks, between which the immense volume of water rushes along, one mass of waves and foam, for a distance of about two hun-

dred yards; it then makes a mad leap of about forty feet, and dashes tumbling over rapids with frantic fury for some distance, and then suddenly resumes the quiet dignity of a great river. It is said that a party of sixty stranger natives were once taunted by the residents into trying to shoot the falls in a canoe, and were, as might have been expected, all drowned. The hot springs were much like those we had before seen; the only remarkable one is called the Crow's Nest. The water has formed a perfect hollow cone of silica about ten feet high. On looking into the cone from above it appears to be built of regular layers of large sticks bound together by incrustations of silica. These sticks give the cone its name of the Crow's Nest, but how the nest came to be so made is a mystery.

In the afternoon I took advantage of a doubt as to whether the game laws apply to game on Maori land to shoot some cock-pheasants, although the shooting season does not begin till May. It is very hard on the natives if they are affected by the game laws, for they would have no means of killing the pheasants, which are increasing so rapidly as to threaten to become a perfect plague to them and their small corn cultivation.

In Taupo Lake, besides carp, there is a most excellent little fish resembling whitebait. They, like everything else in this country, have their legend. Some five hundred years ago a chief with a long name came to Taupo, and grieved to find none of his favorite fish in the lake. After failing to introduce them by natural means, he was driven to have recourse to that most enviable power of obtaining whatever he wished that chiefs seemed to have had then, and have so completely lost now. He accordingly took his cloak, tore it up into small pieces, and cast them into the lake, commanding them to become little fishes, and little fishes they became, and there they are in myriads to this day. Fastidious people think they still have a slightly woolly taste, and I know of no better evidence to support the legend.

Our visit to the hot-lake district came to an end at Taupo. We drove thence some seventy or eighty miles to Napier. We were sorry to leave our friends the Maories with the conviction full in our minds that their days will not be long in their land. I devoutly hope that it may never again be necessary to change our present "sugar and flour" policy for one of "blood and iron."—*Fraser's Magazine.*

"PLEASED WITH A FEATHER."

By Professor GRANT ALLEN.

A MURKY London winter afternoon is not exactly a good opportunity for the pursuit of natural history. The snow lies thick on the pavement outside, half melted into muddy slush; while the fog penetrates through the cracks in the woodwork, and the sun struggles feebly athwart the thick yellow sheet which shuts off his rays from the lifeless earth. If I wish to go on a botanical or entomological excursion to-day, I must perforce content myself with a "Voyage autour de ma Chambre." So I rise listlessly from my easy-chair; perambulate the drawing-room in a sulky mood; peer at the Japanese fans on the mantel-shelf; rearrange for the twentieth time those queer little pipkins we brought on our last vacation ramble from Morlaix; pull about my wife's old Chelsea in a savage fit of tidiness; and finally relapse upon the sofa with a fixed determination to be inconsolably miserable for the rest of the day. Evidently I am suffering from that mysterious British epidemic, the spleen, and I may be shortly expected to plunge incontinently over Waterloo Bridge.

Meanwhile, I find a momentary solace in the Indian cushion which lies under my head. A feather is just pushing its sharper end through the morocco-leather groundwork, between those gorgeous masses of gold, silver, and crimson embroidery; which feather I forthwith begin to egg out, by dexterous side pressure, with admirable industry, worthy of a better cause. My wife, looking up from her crewels, mutters something inarticulate about some one who finds some mischief still for idle hands to do; but her obdurate husband pretends inattention, and finally succeeds in catching the feather-end between his finger and thumb. Now that I have successfully pulled it out, I begin to examine it closely, and bethink myself of how, in brighter summer weather, I dissected a daisy for the benefit of such among the readers of the "Cornhill Magazine" as honored me with their kind attention. I shall take a closer look at this feather, and see if it, too, may not serve as a text for a humble lay-sermon concerning the nature and development of feathers in general, and the birds or human beings who wear them.

For the interesting point about a feather is really this, that *it grew*. It was not made in a moment, like a bullet poured red-hot into a mold: its little airy plumes, branched like a fern into tiny waving filaments, were developed by slow steps, piece after piece, and spikelet after spikelet. And what is true of this particular bit of down which I hold in my fingers, trembling like gossamer at every breath and every pulse, is also true of plumage as a whole in the history of animal evolution. To my mind that great fact, that everything has grown, throws a fresh and wonderful interest into every little object which we

can pick up about our fields or our houses. The old view of creation, which represented it as single and instantaneous, made each creature or each organ seem like a mere piece of molded mechanism, with no history, no puzzle, and no recognizable relation to its like elsewhere. But the new view, which represents creation as continuous, progressive, and regular, teaches us to see in every species or every structure a result of previous causes, an adaptation to preëxisting needs. Thus we are enabled to find in a flower, a fruit, or a feather, innumerable clews which lead us back to its ultimate origin, and give delightful exercise to our intelligence in tracing out the probable steps by which this complex whole has been produced.

I often figure to myself the difference between the two ways of regarding natural objects, by means of the initial letters in an ordinary volume, and the initial letters which Mr. Linley Sambourne draws for us so cleverly in "Punch." Look at the big O of a newspaper leader —it is just a mass of metal, poured into a circular or oval type. But look at the big O which the ingenious artist tricks out for us with social allusions or political innuendoes, and what a world of amusement you will find if you take the trouble to spell out all its quaint devices! See how every curl has some playful hit at a noble lord or an honorable member; how every detail smiles with gentle satire at some passing event or some universal topic. Not a touch but has a meaning for those who will seek it; not a careless little smudge in the corner but brims over with deep purpose and infinite wealth of covert mirth. So it is, I think, with flowers, fruits, or feathers, when once we have learned to look for their hidden hints. This little twist points back to some strange fact in the past history of the species; that unobtrusive spur or knob is the clew to whole volumes of botanical or zoölogical lore. Not a detail but tells of the origin and development of the whole; not a tuft, a spot, or a streak but teems with information for the seeker who has found out the method of seeking aright.

Again, to vary our simile, let us visit some ancient British earthwork or Roman camp. If we go as mere rustics, we see in it all nothing more than a broken ridge of earth on the summit of a rolling down. We are not even sure whether it is really the handiwork of man, or some queer natural formation like the Devil's Dike, the Giant's Causeway, and the parallel roads of Glen Roy. But if we go under the guidance of some skilled archæologist, what a flood of light he is able to throw over its history and its meaning! This row of strongholds, he tells us, formed the frontier line, say between the Welsh of Dorset and the Welsh of Devon. Here the Durotriges and Damnonii, the men of the water-vale and the men of the hills, faced one another from their opposite heights. Sweep round your eye in a semicircle along this series of points, overhanging the valley of the Axe, and you will find every higher summit crowned with a "castle," a rude earthwork raised by the men whom our fathers drove out of the land. That

was their Balkan or Suleiman line, their cordon of border forts, their row of beacons to announce the approach of the hostile hill-men on the war-trail against their homes. Then our antiquary would turn to the work itself, and would point out the various parts, the mode of defense, the simple tactics of those primitive Vaubans. Or else he would show us the Roman detail of the later encampment; the square scar that marked the prætorian quarters; the regular succession of gates and defenses. All this he would tell us from the bare inspection of the existing remains, reconstructing the lost history from his stored-up knowledge of like instances elsewhere.

But I am wandering sadly from my London room and my little feather, this wintry afternoon. Let me look at it once more, and try to realize, in like manner, the story involved in its downy vans.

In the first place, this feather, as an anatomist would tell us, is "a dermal modification"—in other words, an altered bit of the skin. Every part of a plant or animal undergoes changes, our modern teachers say, just in accordance with the external influences which affect it. But the skin of an animal is naturally exposed to many more such surrounding agencies than its internal organs. Accordingly, we find that no structure exhibits such strange variations as the skin. Besides the regular modifications which we see in the scales or horny plates of fishes, the smooth coats or solid shells of reptiles, the feathers of birds, and the hair of mammals, numerous other minor peculiarities occur in almost every species. Such are the horns of cows and goats, the spike of the rhinoceros, the beaks, nails, claws, hoofs, and talons of beasts or birds, and the tail-plumes, ruffs, lappets, crests, and ornamental adjuncts of all the more æsthetic animals. In no class are these variations in the external covering more conspicuous than among the biped tribe whose spoils I am now holding in my hand as the text for our afternoon's discourse.

How birds first came to be winged and feathered we can hardly say as yet. To be sure, most of us have seen a picture, at least, of that strange oölitic monster, the pterodactyl, a saurian with a head like a crow, but having the fore-part protracted into long jaws, fitted with teeth not very dissimilar from those of a crocodile; while its legs were supplied, apparently, with a membrane, by whose aid the creature probably flew about in the same manner as a bat. These real flying dragons recall in many points the appearance of a bird, especially in the skull and the position of the eyes. Moreover, Professors Marsh and Huxley have shown that the earliest fossil birds resemble the pterodactyl and other reptiles in many important peculiarities of structure, far more than their modern representatives. Some of them even possess teeth set in their jaws after a reptilian fashion. Though the evidence still remains very fragmentary, we may regard it as probable that birds are descended from some early reptilian form, more or less like the peterodactyl, if not actually from that partially-winged saurian

itself. But perhaps it is premature to build with any confidence upon such dubious ground; and we may consequently accept the earliest birds on their own responsibility, without inquiring too curiously into their antecedents, or compelling them to produce a genealogical table of their ancestry.

The essential characteristic of a bird consists in the fact that it is a flying animal; and feathers are the kind of skin-covering best adapted to its special manner of life. In their nature and mode of development, feathers closely agree with the hair of mammals; but the differences between them are all of a sort which fit the bird for its aërial existence. We see this fact very clearly if we look at the instance of those birds which do not fly. Running species, such as the ostriches, have downy plumes, in which many of the essential characters of the feather are greatly obscured. In the emu, whose habits are more strictly cursorial, the plumage almost resembles hair. In the cassowary the likeness becomes yet more striking, while the wingless apteryx of New Zealand has not even the few bare quills which stand for wing-feathers in the former bird. So, too, among those sedentary marine birds, the penguins, where the wings have been converted into a sort of fins for diving, the feathers undergo a parallel change into scales. There is reason, indeed, to suspect, as Mr. Lowne has pointed out, that these marine species retain in many ways the primitive characters of the class; and we may perhaps regard them rather as birds in whom the pinions and plumage have never fully developed than as birds in whom they have assumed a new form.

On the other hand, the truest feathers—that is to say, those which exhibit the essential features of a feather in the most marked manner—are specially connected with the act of flight. The general surface of the body is covered with soft down, among which sprout the delicate plumes that form the common covering for warmth and protection; but only on the wings and tail do those long and stiff quills appear which, after all, are the feathers *par excellence*, the models and prototypes of all the rest. Now, it is quite obvious to every one that the wings are the organs of flight, and that the quills are the part by means of which the powerful muscles of the bird are brought to bear upon the sustaining atmosphere. As for the tail, its functions resemble those of a rudder, in directing the course of flight to right or left. The difference between these true flying feathers and the mere clothing of the back and breast is so striking that naturalists have given them separate technical names, as *quills* and *plumes* respectively.

From such facts, and others like them, I think we may arrive at an important conclusion—that feathers have been developed and selected through the habit of flight. Probably our monstrous friend the pterodactyl had only a membranous wing or bit of skin, extending from the elongated outer finger of his forearm to the leg. Such a parachute we still see among the so-called flying-squirrels and lemurs; while in the

bats it has developed into a sort of webbed wing. But if any of the early birds happened to possess an altered hair-like or scale-like covering—the relic, perhaps, of some common reptilio-mammalian ancestor—which afforded them any extra grip upon the air through which they fell rather than floated, then those individuals would thereby gain an extra chance of catching prey or escaping enemies, and therefore of survival in the constant rivalry of species with species. The more perfect these organs became, the more closely adapted to the function of flight, the greater the advantage the bird would derive from their possession, and therefore the better the chance of survival which it would obtain. Thus, apparently, the most aërial birds have the largest and strongest quills, and the most quill-like plumes, while the running and diving birds have either never developed these adjuncts in their highest form, or else have lost them by disuse.

Let me take down one of the peacock's feathers, which stands on the mantelpiece in this Vallauris vase, and closely examine its structure. It consists of a long central shaft, horny and tubular at the lower end, and filled above with a soft, white, spongy matter; while a number of little barbed branches are given off on either side, curiously interlaced by means of tiny hooked filaments, whose myriad threads are far too numerous for the most industrious critic to count up. Everybody knows that this tubular structure combines in the highest degree the mechanical requisites of lightness and strength; and everybody has read that it is employed with the self-same object by human engineers, in such constructions as the great bridges which span the Menai Straits or the St. Lawrence at Montreal. Evidently this peacock's feather, though now converted to a purely ornamental function, was originally developed for the purpose of flight. If I doubt it for a moment, I need only look at the quill-pen in my desk over yonder. That flat blade, close-textured and strongly woven, clearly belongs to a flying organ; and this beautiful mass of green and golden waving plumelets is evidently modeled on the self-same plan. It is useless, or next to useless, now, for flight; but it still bears clear traces of its original function in the structure and arrangement of its shaft and barbs.

Next, let me look at the little downy feather I have abstracted from the Indian cushion. This is not a flying organ, nor did its representative on any early ancestor ever fulfill a similar office. Light, warm, soft, fluffy, its whole object is decidedly that of clothing against chilly weather, and protection against thorns or other rough bodies. Yet when I examine it closely, I see that the same general ground-plan still runs through it, as that which ran through the goose-quill and the peacock's tail-covert. "How comes this?" I ask myself; "here we have a small, delicate, almost fleshy shaft, instead of the horny quill; and a feeble set of downy barbs instead of the strong, well-woven blade: yet the main features remain unaltered, though the function is entirely different. How can I account for this resemblance?"

The case of the emu and the apteryx helps to throw light upon the problem thus disclosed. Where birds fly very little, their feathers never acquire or else soon lose the distinctive quill-like character; but where birds fly much, the quill-producing tendency becomes strong and pronounced. Primarily, this tendency ought to affect only those parts which are used in flight, namely, the wings and tail; and, as a matter of fact, we have seen that these are the parts which exhibit it in the highest degree. It would be almost impossible, however, that a change of such magnitude should be set up in some of the feathers, without to a lesser extent affecting all the rest. We might as well expect that the hair on a certain patch of some animal's skin would grow thick and spike-like, without any corresponding alteration in the rest of his body. True, natural selection does sometimes produce this result for some special purpose, when it is highly desirable that an acquired character should be confined to a small area. But, as a rule, when one part of the skin hardens, like that of a turtle or crocodile, the tendency to bony development shows itself in every part; and when certain hairs become converted into thick spines, like those of the hedgehog, the echidna, and the porcupine, a general bristly tone pervades almost all the coat. The scaly plates of the armadillo and the pangolin in like manner communicate a universal scaliness to the whole external surface of the animal. We may say in simple language that the body has *got into the habit* of producing certain structures, and that the habit extends to analogous parts in which it is not strictly necessary.

This is the case with the flying birds. Some of their feathers—modified scales or hairs—having become specially adapted for flying, all the rest follow suit to a greater or less extent. Indeed, we can hardly imagine how quills could come into existence at all, unless we allow that there must first have been an adventitious tendency toward the production of light-barbed shafts over the whole body. Those birds which exhibited this adventitious habit in the highest degree would become the ancestors of the aërial species, in whom it is still further developed by natural selection; while those birds which exhibited it in the least degree would become the ancestors of the diving, running, and scraping tribes, in whom natural selection favors rather such special adaptations as web-feet, fin-like wings, long and powerful legs, and ornamental plumage.*

The æsthetic philosopher, however (if the reader will permit me to

* Of course no effect in nature is really *accidental*, that is to say, uncaused; but, in organic nature, effects which arise from special collocations of causes, unconnected with the previous habits of a plant or animal, may fairly be called *adventitious*. If they result in some alteration beneficial to the species, the alteration will be further strengthened by natural selection, and its final outcome will be a *purposive* structure—that is to say, a structure specially adapted to its peculiar function. But it must be remembered that almost all purposive structures were in their origin adventitious. I say "almost all" and not "all," because an exception must be made in favor of what Mr. Herbert Spencer calls "functionally-produced structures."

designate myself by such a periphrasis), is far more interested in the modifications which feathers undergo, *after* they have become feathers, than in those which they undergo before reaching that stage of their development. For the infinite variety of coloring, the exquisite tones of metallic sheen, the graceful arrangements of crests, tufts, plumes, and lappets, which render birds such conspicuous objects in our museums or gardens, are all of them due to the pigments or shapes of feathers, and all of them have apparently been produced by the voluntary choice of beautiful mates among the birds themselves.

The modifications of feathers thus originated form, of course, a clew to the tastes of the various birds which possess them; because each species will naturally select such mates as best satisfy its ideas of the beautiful, and so will transmit the admired qualities to its descendants. It is a remarkable fact that the tastes of many birds, indirectly disclosed in such a manner, coincide very closely with the tastes of mankind at large.

Not all birds, however, exhibit equally these æsthetic preferences. Some large families, like those of the hawks, eagles, owls, and night-jars, are noticeable neither for beauty of color nor for richness of song. Other classes, again, like those of our own English hedge-birds, seem rather musical than chromatically inclined in their tastes. As a rule, we may say that birds of prey and nocturnal birds are very deficient in æsthetic feeling, all their energies being apparently directed to swiftness of pursuit and skill in hunting; while, on the other hand, small seed-eating birds, and those which live on little insects or other minute animals, generally expend all their æsthetic sentiment on the faculty of song. But only those birds which live upon fruits, or the mixed nectar and insects extracted from flowers, usually possess brilliant colors.

I have already more than once pointed out to the readers of the "Cornhill Magazine" the probable reason for this peculiar connection.* The eyes of fruit-eating or flower-feeding animals become specially adapted to the stimulation of colored light, and therefore the creatures become capable of receiving special pleasure from such sources. Accordingly, those among their fellows which displayed brilliant colors would prove most attractive, and would be chosen as mates for their beauty. I have instanced before, among the flower-feeding species, the numberless varieties of humming-birds, and the almost equal profusion of sun-birds, to which we may add a few other minor forms, such as the brush-tongued lories; while among the fruit-eaters, the parrots, macaws, cockatoos, toucans, barbets, nutmeg-pigeons, fruit-pigeons, chatterers, and birds-of-paradise, may stand as cases in point. But it will be more interesting here to glance briefly at the various modes in which these colors are produced than to extend the list of species which display them.

* See a paper on "The Origin of Flowers," in "The Popular Science Monthly Supplement" for June, 1878; and another on "The Origin of Fruits," in "The Popular Science Monthly" for September, 1878.

The commonest method of exhibiting color is by means of pigments either in the external coating of the feathers or in their deeper layers. Cases of this sort are too frequent to need special exemplification; but some birds have brilliant hues otherwise displayed, as in the wattles of the common barn-door fowl, the fleshy appendages of the turkey, and the painted face of the carrier-pigeon. The wattled honey-sucker of Australia has two drooping folds of flesh which fall like bonnet-strings under his throat; the king-vulture has his head and neck covered with naked skin of every hue in the rainbow; and the cassowary (by far the most frugivorous of all the ostrich tribe) has the same parts of a brilliant red, variegated with melting shades of blue. In many other birds the beak becomes an ornamental adjunct; and this tendency reaches its furthest development in the bill of the toucan, whose colors almost vie with the humming-bird itself. But the most curious of all such æsthetic modifications is that from which the wax-wings derive their name. In these birds the shafts of certain wing-feathers are prolonged into small, horny expansions, bright scarlet in hue, exactly resembling, both in color and texture, little tags of red sealing-wax.

The metallic luster of feathers is generally due to fine lines on the surface of the barbules, like those which produce the iridescence of mother-of-pearl. Such luster occurs in the sun-birds and humming-birds, and on many other less ornamented species. Sometimes gleaming like gold or bronze, sometimes fading away into jetty black, anon reappearing as glancing outbursts of crimson, azure, or exquisite green, it has gained for the birds on which it appears such poetical names as ruby-throated, topaz-crested, amethystine, golden, emerald, and sapphire. Not only does it occur upon the burnished neck of the dove, but it gives a passing splendor to the sable livery of the crow, and throws a thousand changeful hues over the glossy plumage of the mallard.

But besides the ornamental effects of color and luster, feathers appeal to the æsthetic taste of birds by their form, their arrangement, and their variety. Only the plainest birds have all their plumage exactly uniform and simply disposed. In an immense number of species certain feathers have been specially modified in shape so as to form crests, fan-like tails, lappets, and other ornaments. And just as a good architect lavishes his decorations chiefly on the constructive points of his building, the critical parts, such as arches, doorways, windows, and architraves, so do we find that birds have chosen to place *their* decorative modifications on the most important nodal points of their bodies, and that they generally lavish their richest coloring upon these ornamental adjuncts. This peacock's feather, for instance, formed part of a gorgeous semicircular fan, which composed, as it were, the background or reredos of the whole living picture when expanded, and the train of the majestic sultan when folded in repose. A plume from the neck or back, though still beautiful with golden green and

faintly purplish blue, would not have exhibited those splendid eye-like spots which reflect the sunlight in a mingled mass of glory from this perfect tail-covert. Only in the most fitting positions for decoration do birds, as a rule, expend their choicest designs.*

The feathers of the ostrich naturally occur first to the human investigator of æsthetic taste in birds. The quills of the wing and tail, here purely ornamental in their function, compose the well-known silky plumes of commerce. The common crane has also beautiful elongated wing-feathers, which fall on either side of the tail in graceful waving masses. If we may trust the doubtful pictures which have come down to us, that grotesque and gigantic pigeon, the dodo, possessed similar tufts of ornamental plumage. But the great order of gallinaceous birds, or the hen and turkey tribe, display the most magnificent tails of all, so familiarly known in the peacock and the pheasant family, as well as in the humbler denizens of our English farm-yards.

Crests form another favorite ornamental device among birds, occurring independently in the most different orders. The graceful tuft of the gray heron must have attracted the attention of every observer. Among the pheasants similar decorative adjuncts are common; and the curassow shows this peculiarity in a very beautiful form. With parrots and cockatoos, crests are of frequent occurrence, and they make equally striking features among the humming-birds and sun-birds. Indeed, it may be roughly asserted that those birds which seek their food among flowers and fruits, and which consequently exhibit a taste for bright colors, are also the species in which ornamental tufts of feathers most frequently occur. But crests are also found even among the generally somber and inartistic birds of prey, being by no means unusual in the owls and hawks, while the serpent-eating secretary-bird derives his queer name from the fancied resemblance of his top-knot to a pen stuck behind the ear. Other well-known instances of crested species are the hoopoe, the wax-wing, the golden-crested wren, and many jays. But the umbrella-bird, a Brazilian fruit-crow, exhibits the fullest development of this particular ornament, having the whole head covered by a dome of slender, shining blue feathers, about five inches in length by four and a half in breadth. It may be added that almost all birds which possess these ornaments possess also the power of raising or depressing them at will; and that during the season of courtship the male birds constantly expand all their charms before the eyes of their admiring mates. We have all seen this ostentatious display ourselves in the case of the peacock, the turkey, and the barn-door fowl. It proves almost beyond a doubt the æsthetic purpose and func-

* I say "as a rule," because the hornbills, toucans, vultures, certain pigeons, and a few other species, offend against our ordinary human canons of taste; but the ornaments of birds seldom or never render them ridiculous in our eyes, like those of many highly decorated monkeys.

tion of such otherwise useless, inconvenient, and vitally expensive excrescences.

Sometimes the crest is produced by some other means than that of a mass of plumes. Besides the well-known fleshy comb of our friend chanticleer, there is the horny helmet of our old acquaintance the cassowary, and the quaint protuberances on the beak of the jacana. Most eccentric of all is the device adopted by the hornbills, whose name sufficiently indicates their peculiarity in this respect. The beak in these birds is prolonged above into a single unicorn-like process, extravagantly disproportioned to the general size of its wearer.

On the other hand, it may be noted that most small singing-birds, or other species which live on seeds, grains, insects, and mixed small food, are destitute of tufted ornaments, as well as of brilliant coloring.

The lappets, frills, or other neck-pieces of so many decorated species must not pass entirely unnoticed in this review of æsthetic devices among birds. Beginning with the mere burnished breast-plumage of the pigeon, or the crimson stomacher of the robin, they become at last, in the humming-birds, sun-birds, and other tropical species, the most exquisite drapery of amethyst, topaz, emerald, or golden bronze. The so-called beard of the turkey is a special example of a very aberrant type. The ruff derives his English name from a similar peculiarity.

The birds-of-paradise unite all these modes of ornamentation in the highest degree, and with the most harmonious results. They join the graceful plumes of the ostrich to the dainty coloring of the sun-bird. Crests almost as largely developed as that of the umbrella-bird overshadow their beautiful heads; frills as full as those of the humming-birds fall down in metallic splendor before their gorgeous necks. And, if any proof be wanting of the connection between the nature of the food and the general beauty of the plumage, it may be found in the fact that these royally-attired creatures are first cousins of our own dingy crows and jackdaws; but, while the crow seeks his livelihood among the insects and carrion of an English plowed field, the bird-of-paradise regales his lordly palate on the crimson and purple fruits which gleam out amid the embowering foliage of Malayan forests.

Equally magnificent are the members of the genus *Epimachus*, inhabitants of the same brilliant archipelago. Their long, silky plumes float behind them in the same graceful curves; their burnished necks are adorned with the same glancing hues of ruby and emerald. Yet they are surpassed in one respect by their distant relatives, the lyre-birds, first cousins of our diminutive English wrens. Though destitute of brilliant coloring and metallic sheen, these curious birds exhibit in their long and beautiful tails the only undoubted example among the lower animals of a love for symmetrical patterns.

I have only bethought me now of a few among the countless modifications which feathers undergo, for the æsthetic gratification of their

wearers, or rather of their wearers' mates, and the list might be almost indefinitely prolonged. But it will be better worth while, perhaps, to glance briefly at another set of facts connected with feathers—I mean their artificial employment by human beings for the exactly identical purpose of æsthetic decoration. Could any fact show more clearly the similarity of artistic feeling which runs through the whole animal series than this thought, that man makes use, for his own adornment, of the very self-same beautiful colored baubles which the birds originally developed to charm the eyes of their fastidious brides?

I need not recall by name the various kinds of plumage so employed—the feathers of the ostrich, the marabou, the bird-of-paradise, the emu, the pheasant, and the gull; the sun-birds and the humming-birds mercilessly slaughtered by the million in the Malay Archipelago, Ceylon, and Trinidad to supply the bonnets of London and Paris; the swan's-down, the grebe, the widow-birds, the cockatoos, the parrots, the macaws, which decorate our wives and children with barbaric spoils. It will suffice to remember, in passing, that from the feather mantles of Hawaiian kings, the feather kirtles of American Indians, and the feather mosaics of Mexico, to the plumes of our own court-dress, our own military uniforms, and our own quaintly surviving funeral processions, these same "dermal modifications" of birds have served an æsthetic purpose, better or worse, throughout the whole course of human history.

Nor does the resemblance stop here. Mankind employs tufts of feathers for decorative display in just the same manner as the birds who originally developed them. The Red Indian in his war-paint dressed out his head with a row of quills, arranged in exactly the same order as the top-knot of a hoopoe or a cockatoo. The feather collars of so many savage tribes recall to the letter the frills and lappets of the humming-bird or the epimachus. The ostrich-plumes of our English royal receptions, and the *panache* of our European officers' dress, are adaptations from the primitive idea of the crane and the umbrella-bird. Everywhere, the tuft of feathers is placed on some prominent part of the person—some "constructive point" in the human or avian system of architecture.

A ring at the bell warns me that a visitor is standing at the door. I throw my little feather hastily into the fire, and cut short my reflections to welcome my expected guest. But one last thought occurs to me before I close my afternoon's meditation. To be "pleased with a feather" appeared to the great metaphysical poet of the eighteenth century a mark of childish simplicity. Perhaps it may be so; but, after all, is there not some solace in that new philosophy which can enable one to pass a whole hour, this murky afternoon, in pleasurable contemplation of that tiny plume which seems no contemptible subject of human study to Charles Darwin and Herbert Spencer?—*Cornhill.*

FOOD AND FEEDING.

By Sir HENRY THOMPSON.

I.

I THINK I shall not be far wrong if I say that there are few subjects more important to the well-being of man than the selection and preparation of his food. Our forefathers in their wisdom have provided, by ample and generously endowed organizations, for the dissemination of moral precepts in relation to human conduct, and for the constant supply of sustenance to meet the cravings of religious emotions common to all sorts and conditions of men. In these provisions no student of human nature can fail to recognize the spirit of wisdom and a lofty purpose. But it is not a sign of ancestral wisdom that so little thought has been bestowed on the teaching of what we should eat and drink; that the relations, not only between food and a healthy population, but between food and virtue, between the process of digestion and the state of mind which results from it, have occupied a subordinate place in the practical arrangements of life. No doubt there has long been some practical acknowledgment, on the part of a few educated persons, of the simple fact that a man's temper, and consequently many of his actions, depends on such an alternative as whether he habitually digests his food well or ill; whether the meals which he eats are properly converted into healthy material, suitable for the ceaseless work of building up both muscle and brain; or whether unhealthy products constantly pollute the course of nutritive supply. But the truth of that fact has never been generally admitted to an extent at all comparable with its exceeding importance. It produces no practical result on the habits of men in the least degree commensurate with the pregnant import it contains. For it is certain that an adequate recognition of the value of proper food to the individual in maintaining a high standard of health, in prolonging healthy life (the prolongation of unhealthy life being small gain either to the individual or to the community), and thus largely promoting cheerful temper, prevalent good nature, and improved moral tone, would require almost a revolution in the habits of a large part of the community.

The general outlines of a man's mental character and physical tendencies are doubtless largely determined by the impress of race and family. That is, the scheme of the building, its characteristics and dimensions, are inherited; but to a very large extent the materials and filling in of the framework depend upon his food and training. By the latter term may be understood all that relates to mental and moral and even to physical education, in part already assumed to be fairly provided for, and therefore not further to be considered here. No matter, then, how consummate the scheme of the architect, nor

how vast the design, more or less of failure to rear the edifice results when the materials are ill chosen or wholly unworthy to be used. Many other sources of failure there may be which it is no part of my business to note; but the influence of food is not only itself cardinal in rank, but, by priority of action, gives rise to other and secondary agencies.

The slightest sketch of the commonest types of human life will suffice to illustrate this truth.

To commence, I fear it must be admitted that the majority of British infants are reared on imperfect milk by weak or ill-fed mothers. And thus it follows that the signs of disease, of feeble vitality, or of fretful disposition, may be observed at a very early age, and are apparent in symptons of indigestion or in the cravings of want manifested by the "peevish" and sleepless infant. In circumstances where there is no want of abundant nutriment, over-feeding or complicated forms of food, suitable only for older persons, produce for this infant troubles which are no less grave than those of the former. In the next stage of life, among the poor the child takes his place at the parents' table, where lack of means, as well as of knowledge, deprives him of food more suitable than the rough fare of the adult, and moreover obtains for him, perchance, his little share of beer or gin. On the whole, perhaps he is not much worse off than the child of the well-to-do, who becomes a pet, and is already familiarized with complex and too solid forms of food and stimulating drinks which custom and self-indulgence have placed on the daily table. And soon afterward commence in consequence—and entirely in consequence, a fact it is impossible too much to emphasize—the "sick-headaches" and "bilious attacks," which pursue their victim through half a lifetime, to be exchanged for gout or worse at or before the grand climacteric. And so common are these evils that they are regarded by people in general as a necessary appanage of "poor humanity." No notion can be more erroneous, since it is absolutely true that the complaints referred to are self-engendered, form no necessary part of our physical nature, and for their existence are dependent almost entirely on our habits in relation to food and drink. I except, of course, those cases in which hereditary tendencies are so strong as to produce these evils, despite some care on the part of the unfortunate victim of an ancestor's self-indulgence. Equally, however, on the part of that little-to-be-revered progenitor was ill-chosen food, or more probably excess in quantity, the cause of disease, and not the physical nature of man.

The next stage of boyhood transfers the child just spoken of to a public school, where too often insufficient or inappropriate diet, at the most critical period of growth, has to be supplemented from other sources. It is almost unnecessary to say that chief among these are the pastrycook and the vender of portable provisions, for much of

which latter that skin-stuffed compound of unknown origin, an uncertified sausage, may be accepted as the type.

After this period arise the temptations to drink, among the youth of all classes, whether at beerhouse, tavern, or club. For it has been taught in the bosom of the family, by the father's example and by the mother's precept, that wine, beer, and spirits are useful, nay, necessary to health, and that they augment the strength. And the lessons thus inculcated and too well learned were but steps which led to wider experience in the pursuit of health and strength by larger use of the same means. Under such circumstances it often happens, as the youth grows up, that a flagging appetite or a failing digestion habitually demands a dram before or between meals, and that these are regarded rather as occasions to indulge in variety of liquor than as repasts for nourishing the body. It is not surprising, with such training, that the true object of both eating and drinking is entirely lost sight of. The gratification of acquired tastes usurps the function of that zest which healthy appetite produces; and the intention that food should be adapted to the physical needs of the body and the healthy action of the mind is forgotten altogether. So it often comes to pass that at middle age, when man finds himself in the full current of life's occupations, struggling for preëminence with his fellows, indigestion has become persistent in some of its numerous forms, shortens his "staying power," or spoils his judgment or temper. And, besides all this, few causes are more potent than an incompetent stomach to engender habits of selfishness and egotism. A constant care to provide little personal wants of various kinds, thus rendered necessary, cultivates these sentiments, and they influence the man's whole character in consequence. The poor man, advancing in years, suffers from continuous toil with inadequate food, the supply of which is often diminished by his expenditure for beer, which, although often noxious, he regards as the elixir of life, never to be missed when fair occasion for obtaining it is offered. Many of this class are prematurely crippled by articular disease, etc., and become permanent inmates of the parish workhouse or infirmary.

It must be obvious to everybody how much more of detail might be added to fill in the outlines of this little sketch. It is meager in the extreme: nevertheless it suffices for my purpose; other illustrations may occur hereafter.

But it is necessary to say at this point, and I desire to say it emphatically, that the subject of food need not, even with the views just enunciated, be treated in an ascetic spirit. It is to be considered in relation to a principle, in which we may certainly believe, that aliments most adapted to develop the individual, sound in body and mind, shall not only be most acceptable, but that they may be selected and prepared so as to afford scope for the exercise of a refined taste, and produce a fair degree of that pleasure naturally associated with the

function of the palate, and derived from a study of the table. For it is certain that nine tenths of the gormandism which is practiced, at all events in English society—where for the most part it is a matter of faith without knowledge—is no more a source of gratification to the eater's gustatory sense than it is of digestible sustenance to his body.

Our subject now shapes itself. Food must first be regarded in relation to its value as material to be used for building up and sustaining that composite structure, the human body, under the varied conditions in which it may be placed. Secondly, the selection of food, and the best modes of preparing it, resulting in the production of "the dish," a subject of great extent and importance, must be dealt with very briefly. Lastly, the exercise of taste in relation to the serving of food and drink, or the art of combining dishes to form "a meal," must also be considered.

I shall not regard this as the place in which to offer any scientific definition of the term "food." I shall include within its range all the solid materials popularly so regarded, and therefore eaten. And drink being as necessary as solids for the purpose of digestion, and to supply that large proportion of fluid which the body contains in every mesh and cell thereof, I shall regard as "drink" all the liquids which it is customary to swallow with our meals, although probably very few, if any, of them can be regarded as food in any strict sense of the term.

Food is essential to the body in order to fulfill two distinct purposes, or to supply two distinct wants inseparable from animal life. As certainly as a steam-engine requires fuel, by the combustion or oxidation of which force is called into action for various purposes—as the engine itself requires the mending and replacing of parts wasted in the process of working—so certainly does the animal body require fuel to evoke its force, and material to replace those portions which are necessarily wasted by labor, whether the latter be what we call physical or mental—that is, of limbs or of brain. The material which is competent to supply both requirements is a complete or perfect food. Examples of complete food exist in milk and the egg, sufficing as these do for all the wants of the young animal during the period of early growth. Nevertheless, a single animal product like either of the two named, although complex in itself, is not more perfect than an artificial combination of various simpler substances, provided the mixture (dish or meal) contains all the elements required in due proportion for the purposes of the body.

It would be out of place to occupy much space with those elementary details of the chemical constitution of the body which may be found in any small manual of human physiology;* but for the right

* Such as "Physiology," Science Primer, by M. Foster, M. A., M. D. (Macmillan); "Lessons in Elementary Physiology," by Professor Huxley (Macmillan). For a full consideration of the subject, Dr. Pavy's very complete "Treatise on Food and Dietetics" (Churchill, London, 1875).

understanding of our subject, a brief sketch must be presented. Let it suffice to say that carbon, hydrogen, and oxygen, the three all-pervading elements of the vegetable world, enter largely into the composition of the animal body; and that the two former especially constitute a fuel the oxidization of which produces animal heat, and develops the force in its varied forms, physical and mental, which the body is capable of exerting. Besides these, nitrogen, obtainable from certain vegetable products, not from all, but forming definite combinations with the three elements just named, is essential to the repair and reproduction of the body itself, being one of its most important constituents. Lastly must be named several other elements which, in small proportions, are also essential constituents of the body, such as sulphur, phosphorus, salts of lime, magnesia, potash, etc., with traces of iron and other metals. All these must be present in the food supplied, otherwise animal existence can not be supported; and all are found in the vegetable kingdom, and may be obtained directly therefrom by man in feeding on vegetables alone.* But the process of obtaining and combining these simple elements into the more complex forms which constitute the bases of animal tissues—definite compounds of nitrogen with carbon, hydrogen and oxygen—is also accomplished by the lower animals, which are exclusively vegetable feeders. These animals we can consume as food, and thus procure, if we please, ready prepared for our purpose, the materials of flesh, sinew, and bone for immediate use. We obtain also from the animal milk and the egg, already said to be "perfect" foods; and they are so because they contain the nitrogenous compounds referred to, fatty matter abundantly, and the various saline or mineral matters requisite. But compounds simpler in form than the preceding, of a non-nitrogenous kind, that is, of carbon, hydrogen, and oxygen only, are necessary as food for the production of animal heat and force. These consist, first, of the fat of animals of various kinds, and of butter; and from the vegetable kingdom, of the fatty matter which exists in grain and legumes, and largely in the olive and in many seeds; secondly, of the starchy matters, all derived from vegetables, such as a large part of wheaten and other flour, rice, arrowroot, and potatoes, together with sugar, gum, and other minor vegetable products of a similar kind. The fats form the more important group of the two, both in relation to the production of heat and force; and without a constant supply of fat as food the body would cease to exist. The vegetable-eater, pure and simple, can therefore extract from his food all the principles necessary for the growth and support of the body as well as for the production

* The vegetable kingdom comprehends the cereals, legumes, roots, starches, sugar, herbs, and fruits. Persons who style themselves vegetarians often consume milk, eggs, butter, and lard, which are choice foods from the animal kingdom. There are other persons, of course, who are strictly vegetable-eaters, and such alone have any right to the title of vegetarians.

of heat and force, provided that he selects vegetables which contain all the essential elements named. But he must for this purpose consume the best cereals, wheat or oats, or the legumes, beans, peas, or lentils; or he must swallow and digest a large weight of vegetable matter of less nutritive value, and therefore containing at least one element in large excess, in order to obtain all the elements he needs. Thus the Irishman requires ten to eleven pounds of potatoes daily, which contain chiefly starch, very little nitrogen, and scarcely any fat; hence he obtains, when he can, some buttermilk or bacon, or a herring to supply the deficiency. The Highlander, living mainly on oatmeal, requires a much smaller weight, since this grain contains not only starch, but much nitrogen and a fair amount of fat, although not quite sufficient for his purpose, which is usually supplied by adding milk or a little bacon to his diet. On the other hand, the man who lives chiefly or largely on flesh and eggs as well as bread obtains precisely the same principles, but served in a concentrated form, and a weight of about two or three pounds of such food is a full equivalent to the Irishman's ten or eleven pounds of potatoes and extras. The meat-eater's digestion is taxed with a far less quantity of solid, but that very concentration in regard of quality entails on some stomachs an expenditure of force in digestion equal to that required by the vegetable-eater to assimilate his much larger portions. And it must be admitted as a fact beyond question that some persons are stronger and more healthy who live chiefly or altogether on vegetables, while there are many others for whom a proportion of animal food appears to be desirable, if not necessary. In studying this matter individual habit must be taken into account. An animal feeder may by slow degrees become a vegetarian, without loss of weight or strength, not without feeling some inconvenience in the process; but a sudden change in diet in this direction is for a time almost equivalent to starvation. The digestive organs require a considerable period to accommodate themselves to the performance of work different from that to which they have been long accustomed, and in some constitutions might fail altogether in the attempt. Besides, in matters of diet essentially, many persons have individual peculiarities; and while certain fixed principles exist, such as those already laid down as absolutely cardinal, in the detail of their application to each man's wants an infinity of stomach eccentricities is to be reckoned on. The old proverb expresses the fact strongly but truly: "What is one man's meat is another man's poison." Yet nothing is more common—and one rarely leaves a social dinner-table without observing it—than to hear some good-natured person recommending to his neighbor, with a confidence rarely found except in alliance with profound ignorance of the matter in hand, some special form of food or drink, or system of diet, solely because the adviser happens to have found it useful to himself!

It will be interesting now to take a general but brief survey of the

vast range of materials which civilized man has at his command for the purpose of food: these few preliminary remarks on the chemical constituents of food having been intended to aid in appreciating the value of different kinds.

Commencing with the vegetable kingdom, from which our early progenitors, probably during long ages, drew all their sustenance, the cereals, or cultivated grasses, come first, as containing all the elements necessary to life, and being therefore most largely consumed. Wheat and its congeners, which rank highest in quality, had been distinguished in the form of bread, as "the staff of life," long before the physiological demonstration of the fact had been attained. Wheat, oats, rye, and barley, maize and rice, are the chief members of this group; wheat containing the most nitrogenous or flesh-forming material, besides abundance of starch, a moderate amount of fat, together with sufficient saline and mineral elements. Rice, on the other hand, contains very little nitrogen, fat, and mineral constituents, but starch in great abundance; while maize, with a fair supply of nitrogenous and starchy matter, contains the most fat or heat-producing material of the whole group. As derived from wheat must be named the valuable aliments, macaroni and all the Italian pastes. Derived from barley is malt-saccharine, parent of the large family of fermented liquors known as beer. And from various other grains are obtained, by fermentation and distillation, several forms of ardent spirit. Vinegar, best when produced from the grape, is also largely made from grain.

The legumes, such as beans, lentils, and peas, form an aliment of great value, containing more nitrogen even than the cereals, but with fat in very small proportion, while starchy matter and the mineral elements abound in both groups.

The tuber finds its type in the potato, which contains much starch, little nitrogen, and almost no fat; in the yam also. The roots may be illustrated by the beet, carrot, parsnip, and turnip, all containing little nitrogen, but much sugar, and water in large proportion. Derived from roots and stems of foreign growth, we have arrowroot, tapioca, and sago, all starches and destitute of nitrogen. Fatty matter is abundantly found in the olive, which supplies a large part of the world with an important article of food. The almond and other seeds are also fruitful sources of oil.

Under the term "green vegetables," a few leading plants may be enumerated as types of the vast natural supplies which everywhere exist: The entire cabbage tribe in great variety; lettuces, endive, and cresses; spinach, seakale, asparagus, celery, onions, artichokes, and tomato, all valuable not so much for nutritive property, which is inconsiderable, as for admixture with other food chiefly on account of salts which they contain, and for their appetizing aroma and varied flavors. Thus condiments are useful, as the sweet and aromatic spices, the peppers, mustard, and the various potherbs, so essential to an agreeable

cuisine. Sea-weeds, as laver, and the whole tribe of mushrooms should be named, as ranking much higher in nutritive value than green vegetables. Pumpkins, marrows, and cucumbers, chestnuts, and other nuts largely support life in some countries. The bread-fruit is of high value; so also are the cocoanut and the banana in tropical climates.

Lastly must be named all those delicious but not very nutritive products of most varied kind and source, grouped under the name of fruits. These are characterized chiefly by the presence of sugar, acid, vegetable jelly, and some saline matter, often combined with scent and flavor of exquisite quality. Derived from grapes as its chief source, stands wine in its innumerable varieties, so closely associated by all civilized nations with the use of aliments, although not universally admitted to rank in technical language as a food. Next may be named sugar in its various forms, a non-nitrogenous product of great value, and in a less degree, honey. No less important are the tea-plant, the coffee-berry, and the seeds of the cacao-tree.

There is a single element belonging to the mineral kingdom which is taken in its natural state as an addition to food, namely, common salt; and it is so universally recognized as necessary that it can not be omitted here. The foregoing list possesses no claim to be exhaustive, only to be fairly typical and suggestive; many omissions, which some may think important, doubtless exist. In like manner, a rapid survey may be taken of the animal kingdom.

First, the flesh of domestic quadrupeds: the ox and sheep, both adult and young; the pig; the horse and ass, chiefly in France. Milk, butter, and cheese in endless variety are derived chiefly from this group. More or less wild are the red deer, the fallow deer, and the roe deer. As game, the hare and rabbit; abroad, the bison, wild boar, bear, chamois, and kangaroo, are esteemed for food among civilized nations; but many other animals are eaten by half-civilized and savage peoples. All these are rich in nitrogen, fatty matters, and saline materials.

Among birds, we have domestic poultry in great variety of size and quality, with eggs in great abundance furnished chiefly by this class. All the wild fowl and aquatic birds; the pigeon tribe and the small birds. Winged game in all its well-known variety.

Of fish it is unnecessary to enumerate the enormous supply and the various species which exist everywhere, and especially on our own shores, from the sturgeon to whitebait, besides those in fresh-water rivers and lakes. All of them furnish nitrogenous matter largely, but, and particularly the white fish, possess fat in very small proportion, and little of saline materials. The salmon, mackerel, and herring tribes have more fat, the last-named in considerable quantity, forming a useful food well calculated to supplement cereal aliments, and largely adopted for the purpose both in the south and north of Europe.

The so-called reptiles furnish turtle, tortoise, and edible frog.

Among articulated animals are the lobsters, crabs, and shrimps. Among mollusks, the oyster and all the shellfish, which, as well as the preceding animals, in chemical composition closely resemble that of fish properly so called.

I shall not enter on a discussion of the question, Is man designed to be a vegetable feeder, or a flesh-eating or an omnivorous animal? Nor shall his teeth or other organs be examined in reference thereto. Any evidence to be found by anatomical investigation can only be safely regarded as showing what man is and has been. That he has been and is omnivorous to the extent of his means, there can exist no doubt. Whether he has been generally prudent or happy in his choice of food and drink is highly improbable, seeing that until very recently he has possessed no certain knowledge touching the relations which matters used as food hold with respect to the structure and wants of his body, and that such recent knowledge has been confined to a very few individuals. Whatever sound practice he may have attained, and it is not inconsiderable, in his choice and treatment of food, is the result of many centuries of empirical observation, the process of which has been attended with much disastrous failure and some damage to the experimenters. No doubt, much unsound constitution and proclivity to certain diseases result from the persistent use through many generations of improper food and drink.

Speaking in general terms, man seems, at the present time, prone to choose foods which are unnecessarily concentrated and too rich in nitrogenous or flesh-forming material, and to consume more in quantity than is necessary for the healthy performance of the animal functions. He is apt to leave out of sight the great difference, in relation to both quantity and quality of food, which different habits of life demand, e. g., between the habits of those who are chiefly sedentary and brain-workers and of those who are active and exercise muscle more than brain. He makes very small account of the different requirements by the child, the mature adult, and the declining or aged person. And he seems to be still less aware of the frequent existence of notable individual peculiarities in relation to the tolerance of certain aliments and drinks. As a rule, man has little knowledge of, or interest in, the processes by which food is prepared for the table, or the conditions necessary to the healthy digestion of it by himself. Until a tolerably high standard of civilization is reached, he cares more for quantity than quality, desires little variety, and regards as impertinent an innovation in the shape of a new aliment, expecting the same food at the same hour daily, his enjoyment of which apparently greatly depends on his ability to swallow the portion with extreme rapidity, that he may apply himself to some other and more important occupation without delay. Eating is treated, in fact, by multitudes much as they are disposed to treat religious duty—which eating assuredly is—that is, as a duty which is generally irksome, but unfortunately necessary to be

performed. As to any exercise of taste in the serving or in the combining of different foods at a meal, the subject is completely out of reach of the great majority of people, and is as little comprehended by them as the structure and harmonies of a symphony are by the first whistling boy one chances to meet in the street. The intelligent reader who has sufficient interest in this subject to have followed me thus far, may fancy this a sketch from savage life. On the contrary, I can assure him that ignorance and indifference to the nature and object of food mark the condition of a large majority of the so-called educated people of this country. Men even boast of their ignorance of so trivial a subject, regard it as unworthy the exercise of their powers, and—small compliment to their wives and sisters—fit only for the occupation of women.

Admitting man, then, to be physically so constituted as to be able to derive all that is necessary to the healthy performance of all his functions from the animal or from the vegetable kingdom, either singly or combined, he can scarcely be regarded otherwise than as qualified to be an omnivorous animal. Add to this fact his possession of an intelligence which enables him to obtain food of all kinds and climes, to investigate its qualities, and to render it more fit for digestion by heat—powers which no other animal possesses—and there appears no *a priori* reason for limiting his diet to products of either kingdom exclusively.

It is a matter of great interest to ascertain what have become, under the empirical conditions named, the staple foods of the common people of various climates and races—what, in short, supports the life and labor of the chief part of the world's population.

In the tropics and adjacent portions of the temperate zones, high temperature being incompatible with the physical activity familiar to northern races, a very little nitrogenous material suffices, since the waste of muscle is small. Only a moderate quantity of fat is taken, the demand for heat-production being inconsiderable. The chiefly starchy products supply nearly all the nutriment required, and such are found in rice, millet, etc. Rice by itself is the principal food of the wide zone thus indicated, including a large part of China, the East Indies, part of Africa and America, and also the West Indies. Small additions, where obtainable, are made of other seeds, of oil, butter, etc.; and, as temperature decreases by distance from the equator, some fish, fowl, or other light form of animal food, are added.

In the north of Africa, Arabia, and some neighboring parts, the date, which contains sugar in abundance, is largely eaten, as well as maize and other cereals.

Crossing to Europe, the southern Italian is found subsisting on macaroni, legumes, rice, fruits, and salads, with oil, cheese, fish, and small birds, but very little meat. More northward, besides fish and a little meat, maize is the chief aliment, rye and other cereals taking a

second place. The chestnut also is largely eaten by the poorer population, both it and maize containing more fatty matter than wheat, oats, and legumes.

In Spain, the inhabitants subsist chiefly on maize and rice, with some wheat and legumes, among them the garbanzo or "chick pea," and one of the principal vegetable components of the national *olla*, which contains also a considerable proportion of animal food in variety, as bacon, sausage, fowl, etc. Fruit is fine and abundant; especially so are grapes, figs, and melons. There is little or no butter, the universal substitute for which is olive-oil, produced in great quantity. Fowls and the pig furnish the chief animal food, and garlic is the favorite condiment.

Going northward, flesh of all kinds occupies a more considerable place in the dietary. In France the garden vegetables and legumes form an important staple of diet for all classes; but the very numerous small land proprietors subsist largely on the direct products of the soil, adding little more than milk, poultry, and eggs, the produce of their small farms. The national *pot-au-feu* is an admirable mixed dish, in which a small portion of meat is made to yield all its nutritive qualities, and to go far in mingling its odor and savor with those of the fragrant vegetables which are so largely added to the stock. The stock-meat eaten hot, or often cold with plenty of green salad and oil, doubtless the most palatable mode of serving it, thus affords a source of fat, if not otherwise provided for by butter, cheese, etc.

Throughout the German Empire, the cereals, legumes, greens, roots, and fruits supply an important proportion of the food consumed by the common population. Wheaten bread chiefly, and some made from rye, also beans and peas, are used abundantly. Potatoes and green vegetables of all kinds are served in numerous ways, but largely in soups, a favorite dish. Meats, chiefly pork, are greatly esteemed in the form of sausage, and appear also as small portions or joints, but freely garnished with vegetables, on the tables of those who can afford animal diet. Going northward, where the climate is no longer adapted for the production of wheat, as in parts of Russia, rye and oats form the staple food from the vegetable kingdom, associated with an increased quantity of meat and fatty materials.

Lastly, it is well known that the inhabitants of the Arctic zone are compelled to consume large quantities of oily matter, in order to generate heat abundantly; and also that animal food is necessarily the staple of their dietary. Vegetables, which, moreover, are not producible in so severe a climate, would there be wholly inadequate to support life.

We will now consider the food which the English peasant and artisan provide. The former lives, for the most part, on wheaten bread and cheese, with occasionally a little bacon, some potatoes, and perhaps garden greens: it is rarely indeed that he can obtain flesh. To

this dietary the artisan adds meat, mostly beef or mutton, and some butter. A piece of fresh and therefore not tender beef is baked, or cooked in a frying-pan, in the latter case becoming a hard, indigestible, and wasted morsel; by the former process a somewhat better dish is produced, the meat being usually surrounded by potatoes or by a layer of some batter, since both contain starchy products and absorb the fat which leaves the meat. The food of the peasant might, however, be cheaper and better; while the provision of the artisan is simply extravagant and bad. At this period of our national history, when food is scarce, and the supply of meat insufficient to meet the demand which our national habits of feeding perpetuate, it is an object of the first importance to consider whether other aliments can be obtained at a cheaper rate, and at the same time equal in quality to those of the existing dietary. Many believe that this object may be accomplished without difficulty, and that the chief obstacle to improvement in the food supply, not only of the classes referred to, but in that of the English table generally, is the common prejudice which exists against any aliment not yet widely known or tried. The one idea which the working classes possess in relation to improvement in diet, and which they invariably realize when wages are high, is the inordinate use of butcher's meat. To make this the chief element of at least three meals daily, and to despise bread and vegetables, is for them no less a sign of taste than a declaration of belief in the perfection of such food for the purposes of nutrition.

We have already seen that not only can all that is necessary to the human body be supplied by the vegetable kingdom solely, but that, as a matter of fact, the world's population is to a large extent supported by vegetable products. Such form, at all events, the most wholesome and agreeable diet for the inhabitants of the tropics. Between about forty and nearly sixty degrees of latitude we find large populations of fine races trained to be the best laborers in the world on little more than cereals and legumes, with milk (cheese and butter), as food; that little consisting of irregular and scanty supplies of fish, flesh, and fatty matter. In colder regions vegetable products are hardly to be obtained, and flesh and fat are indispensable. Thus man is clearly omnivorous; while *men* may be advantageously vegetarian in one climate, mixed eaters in another, and exclusively flesh-eaters in a third.

I have not hesitated to say that Englishmen generally have adopted a diet adapted for a somewhat more northerly latitude than that which they occupy; that the cost of their food is therefore far greater than it need be, and that much of their peculiar forms of indigestion and resulting chronic disease is another necessary consequence of the same error. They consume too much animal food, particularly the flesh of cattle. For all who are occupied with severe and continuous mechanical labor, a mixed diet, of which cereals and legumes form a large portion, and meat, fish, eggs, and milk form a

moderate proportion, is more nutritious and wholesome than chiefly animal food. For those whose labor is chiefly mental, and whose muscular exercise is inconsiderable, still less of concentrated nitrogenous food is desirable. A liberal supply of cereals and legumes, with fish, and flesh in its lighter forms, will better sustain such activity than large portions of butcher's meat twice or thrice a day. Then again it is absolutely certain, contrary to the popular belief as this is, that while a good supply of food is essential during the period of growth and active middle life, a diminished supply is no less essential to health and prolongation of life during declining years, when physical exertion is small, and the digestive faculty sometimes becomes less powerful also. I shall not regard it as within my province here to dilate on this topic, but shall assert that the "supporting" of aged persons, as it is termed, with increased quantities of food and stimulant, is an error of cardinal importance. These things being so, a consideration of no small concern arises in relation to the economical management of the national resources. For it is a fair computation that every acre of land devoted to the production of meat is capable of becoming the source of three or four times the amount of produce of equivalent value as food, if devoted to the production of grain. In other words, a given area of land cropped with cereals and legumes will support a population more than three times as numerous as that which can be sustained on the same land devoted to the growth of cattle. Moreover, the corn-land will produce, almost without extra cost, a considerable quantity of animal food, in the form of pigs and poultry, from the offal or coarser parts of vegetable produce which is unsuitable for human consumption.

Thus this country purchases every year a large and increasing quantity of corn and flour from foreign countries, while more of our own land is yearly devoted to grazing purposes. The value of corn and flour imported by Great Britain in 1877 was no less than £63,536,-322, while in 1875 it was only just over £53,000,000. The increased import during the last thirty-two years is well exhibited in the following extract: "In 1846 the imports of corn and flour amounted to seventeen pounds weight per head of population; in 1855 they had risen to seventy pounds per head; and in 1865 to ninety-three pounds weight per head of population. Finally, in 1877 the imports of corn and flour amounted to one hundred and seventy pounds weight per head of population of the United Kingdom." *

Lastly, those who are interested in the national supply of food must lament that, while Great Britain possesses perhaps the best opportunities in the world for securing a large and cheap supply of fish, she fails to attain it, and procures so little only that it is to the great majority of the inhabitants an expensive luxury. Fish is a food of great value; nevertheless, it ought in this country to be one of the

* "Statesman's Year Book," 1879, p. 258.

cheapest aliments, since production and growth cost absolutely nothing, only the expenses of catching and of a short transport being incurred.

Having enunciated some general principles which it is important should first be established, I shall offer briefly an illustration or two of the manner in which they may be applied. This brings us to the second division of the subject, viz., the practical treatment of certain aliments in order to render them suitable for food. Dealing first with that of the agricultural laborer, our object is to economize his small pittance, to give him, if possible, a rather more nutritive, wholesome, and agreeable dish—he can have but one—that his means have hitherto furnished. But here there is little scope for change; already said to live chiefly on bread and cheese, with occasionally bacon, two indications only for improvement can be followed, viz., augmentation of nitrogenous matter to meet the wear and tear of the body in daily hard labor, and of fatty matter to furnish heat and force. A fair proportion of meat, one of the best means of fulfilling them, is not within his reach. First, his daily bread ought to contain all the constituents of the wheat, instead of being made of flour from which most of the mineral elements have been removed. But beans and peas are richer in nitrogen than wheat, and equal it in starch, mineral matters, and fat, the last being in very small quantity, while maize has three times their proportion of fat. Hence all of these would be useful additions to his dietary, being cheaper than wheat in the market, although, the retail demand being at present small, they may not be so in the small shops. As an illustration of the value of legumes combined with fat, it may be remembered how well the Erbswurst supported the work of the German armies during the winter of 1870–'71, an instructive lesson for us in England at the present moment. It consists of a simple pea-soup mixed with a certain proportion of bacon or lard, and dried so as to be portable, constituting in very small compass a perfect food, especially suitable for supporting muscular expenditure and exposure to cold. Better than any flesh, certainly any which could be transported with ease, the cost was not more than half that of ordinary meat. It was better also, because the form of the food is one in which it is readily accessible and easily digested; it was relished cold, or could be converted in a few minutes into good soup with boiling water. But for our laborer probably the best of the legumes is the haricot bean, red or white, the dried mature bean of the plant whose pods we eat in the early green state as "French beans." For this purpose they may be treated thus: Soak, say, a quart of the dried haricots in cold water for about twelve hours, after which place them in a saucepan, with two quarts of cold water and a little salt, on the fire; when boiling remove to the corner and simmer slowly until the beans are tender; the time required being about two to three hours. This quantity will fill a large dish, and may be

eaten with salt and pepper. It will be greatly improved at small cost by the addition of a bit of butter, or of melted butter with parsley, or if an onion or two have been sliced and stewed with the haricots. A better dish still may be made by putting all, or part, after boiling, into a shallow frying-pan and lightly frying for a few minutes with a little lard and some sliced onions. With a few slices of bacon added, a comparatively luxurious and highly nutritive meal may be made. But there is still in the saucepan, after boiling, a residue of value, which the French peasant's wife, who turns everything to account, utilizes in a manner quite incomprehensible to the Englishwoman. The water in which dried haricots have stewed, and also that in which green French beans have been boiled, contain a proportion of nutritious matter. The Frenchwoman always preserves this liquor carefully, cuts and fries some onions, adds these and some thick slices of bread, a little salt and pepper with a pot-herb or two from the corner of the garden, and thus serves hot an agreeable and useful *croûte au pot.* It ought to be added that the haricots so largely used by the working classes throughout Europe are not precisely either "red" or "white," but some cheaper local varieties, known as *haricots du pays.* These, I am assured on good authority, could be supplied here at about twopence a pound, their quality as food being not inferior to other kinds.

But haricots—let them be the fine white Soissons—are good enough to be welcome at any table. A roast leg or shoulder of mutton should be garnished by a pint boiled as just directed, lying in the gravy of the dish; and some persons think that, with a good supply of the meat gravy, and a little salt and pepper, "the haricots are by no means the worst part of the mutton." Then with a smooth *purée* of mild onions, which have been previously sliced, fried brown, and stewed, served freely as sauce, our leg of mutton and haricots become the *gigot à la bretonne* well known to all lovers of wholesome and savory cookery. Next, white haricots stewed until soft, made into a rather thick *purée,* delicately flavored by adding a small portion of white *purée* of onions (not browned by frying as in the preceding sauce), produce an admirable garnish for the center of a dish of small cutlets, or an *entrée* of fowl, etc. Again, the same haricot *purée* blended with a veal stock, well flavored with fresh vegetables, furnishes an admirable and nutritious white soup. The red haricots in like manner with a beef stock make a superlative brown soup, which, with the addition of portions of game, especially of hare, forms, for those who do not despise economy in *cuisine* where the result attained is excellent, a soup which in texture and in flavor would by many persons not be distinguishable from a common *purée* of game itself. Stewed haricots also furnish, when cold, an admirable salad, improved by adding slices of tomato, etc., the oil supplying the one element in which the bean is deficient; and a perfectly nutritious food is produced for those who can digest it

—and they are numerous—in this form. The same principle, it may be observed, has, although empirically, produced the well-known dishes of beans and bacon, ham and green peas, boiled pork and pease-pudding, all of them old and popular but scientific combinations. Thus also the French, serving *petits pois* as a separate dish, add butter freely and a dash of sugar, the former making the compound physiologically complete, the latter agreeably heightening the natural sweetness of the vegetable.

Let me recall, at the close of these few hints about the haricot, the fact that there is no product of the vegetable kingdom so nutritious; holding its own in this respect, as it well can, even against the beef and mutton of the animal kingdom. The haricot ranks just above lentils, which have been so much praised of late, and rightly, the haricot being also to most palates more agreeable. By most stomachs, too, haricots are more easily digested than meat is; and, consuming weight for weight, the eater feels lighter and less oppressed, as a rule, after the leguminous dish; while the comparative cost is very greatly in favor of the latter. I do not of course overlook in the dish of simple haricots the absence of savory odors proper to well-cooked meat; but nothing is easier than to combine one part of meat with two parts of haricots, adding vegetables and garden herbs, so as to produce a stew which shall be more nutritious, wholesome, and palatable than a stew of all meat with vegetables, and no haricots. Moreover, the cost of the latter will be more than double that of the former.

I have just adverted to the bread of the laborer, and recommended that it should be made from entire wheat meal; but it should not be so coarsely ground as that commonly sold in London as "whole meal." The coarseness of "whole meal" is a condition designed to exert a specific effect on the digestion for those who need it, and, useful as it is in its place, is not desirable for the average population referred to. It is worth observing, in relation to this coarse meal, that it will not produce light agreeable bread in the form of loaves: they usually have either hard, flinty crusts, or soft, dough-like interiors; but the following treatment, after a trial or two, will be found to produce excellent and most palatable bread: To two pounds of whole meal add half a pound of fine flour and a sufficient quantity of baking-powder and salt; when these are well mixed, rub in about two ounces of butter, and make into dough with half milk and water, or with all milk if preferred. Make rapidly into flat cakes like "tea-cakes," and bake in a quick oven, leaving them afterward to finish thoroughly at a lower temperature. The butter and milk supply fatty matter in which the wheat is somewhat deficient; all the saline and mineral matters of the husk are retained; and thus a more nutritive form of bread can not be made. Moreover, it retains the natural flavor of the wheat, in place of the insipidity which is characteristic of fine flour, although it is indisputable that bread produced from the latter, especially at Paris and

Vienna, is unrivaled for delicacy, texture, and color. Whole meal may be bought; but mills are now cheaply made for home use, and wheat may be ground to any degree of coarseness desired.

Here illustration by recipe must cease; although it would be an easy task to fill a volume with matter of this kind, illustrating the ample means which exist for diminishing somewhat the present wasteful use of "butcher's meats" with positive advantage to the consumer. Many facts in support of this position will appear as we proceed. But another important object in furnishing the foregoing details is to point out how combinations of the nitrogenous, starchy, fatty, and mineral elements may be made, in well-proportioned mixtures, so as to produce what I have termed a "perfect" dish—perfect, that is, so far as the chief indication is concerned, viz., one which supplies every demand of the body, without containing any one element in undue proportion. For it is obvious that one or two of these elements may exist in injurious excess, especially for delicate stomachs, the varied peculiarities of which, as before insisted on, must sometimes render necessary a modification of all rules. Thus it is easy to make the fatty constituent too large, and thereby derange digestion, a result frequently experienced by persons of sedentary habits, to whom a little pastry, a morsel of *foie gras*, or a rich cream is a source of great discomfort, or of a "bilious attack"; while the laborer, who requires much fatty fuel for his work, would have no difficulty in consuming a large quantity of such compounds with advantage. Nitrogenous matter also is commonly supplied beyond the eater's wants; and, if more is consumed than can be used for the purposes which such aliment subserves, it must be eliminated in some way from the system. This process of elimination, it suffices to say here, is undoubtedly a prolific cause of disease, such as gout and its allies, as well as other affections of a serious character, which would in all probability exist to a very small extent, were it not the habit of those who, being able to obtain the strong or butcher's meats, eat them daily year after year, in larger quantity than the constitution can assimilate.

Quitting the subject of wheat and the leguminous seeds, it will be interesting to review briefly the combinations of rice, which furnishes so large a portion of the world with a vegetable staple of diet. Remembering that it contains chiefly starch, with nitrogen in small proportion, and almost no fat or mineral elements, and just sufficing perhaps to meet the wants of an inactive population in a tropical climate, the first addition necessary for people beyond this limit will be fat, and, after that, more nitrogen. Hence the first effort to make a dish of rice "complete" is the addition of butter and a little Parmesan cheese, in the simple *risotto*, from which, as a starting-point, improvement, both for nutritive purposes and for the demands of the palate, may be carried to any extent. Fresh additions are made in the shape of marrow, of morsels of liver, etc., of meat broth with onion and spice,

which constitute the mixture, when well prepared, nutritious and highly agreeable. The analogue of this mainly Italian dish is the *pilau* or *pilaff* of the Orientals, consisting as it does of nearly the same materials, but differently arranged. The curry of poultry and the kedgeree of fish are further varieties which it is unnecessary to describe. Follow the same combination to Spain, where we find a popular national dish, but slightly differing from the foregoing, in the *pollo con arroz*, which consists of abundance of rice, steeped in a little broth and containing morsels of fowl, bacon, and sausage, with appetizing spices, and sufficing for an excellent meal.

Another farinaceous product of world-wide use is the maize or Indian corn. With a fair amount of nitrogen, starch, and mineral elements, it contains also a good proportion of fat, and is made into bread, cakes, and puddings of various kinds. It is complete, but susceptible of improvement by the addition of nitrogen. Hence, in the United States, where it is largely used, it is often eaten with beans under the name of "succotash." In Italy it is ground into the beautiful yellow flour which is conspicuous in the streets of almost every town; when made into a firm paste by boiling in water, and sprinkled with Parmesan cheese, a nitrogenous aliment, it becomes what is known as *polenta*, and is largely consumed with some relish in the shape of fried fish, sardines, sausage, little birds, or morsels of fowl or goose, by which, of course, fresh nitrogen is added. Macaroni has been already alluded to; although rich in nitrogenous and starchy materials, it is deficient in fat. Hence it is boiled and eaten with butter and parmesan (*à l'italienne*) and with tomatoes, which furnish saline matters, with meat gravy, or with milk.

Nearer home the potato forms a vegetable basis in composition closely resembling rice, and requiring therefore additions of nitrogenous and fatty elements. The Irishman's inseparable ally, the pig, is the natural, and to him necessary, complement of the tuber, making the latter a complete and palatable dish. The every-day combination of mashed potato and sausage is an application of the same principle. In the absence of pork, the potato-eater substitutes a cheap oily fish, the herring. The combination of fatty material with the potato is still further illustrated in our baked potato and butter, in fried potatoes in their endless variety of form, in potato mashed with milk or cream, served in the ordinary way with *maître d'hôtel* butter, or arriving at the most perfect and finished form in the *pommes de terre sautées au beurre* of a first-class French restaurant, where it becomes almost a *plat de luxe*. Even the simple bread and butter or bread and cheese of our own country equally owe their form and popularity to physiological necessity; the deficient fat of the bread being supplemented by the fatty elements of each addition, the cheese supplying also its proportion of nitrogenous matter, which exists so largely in its peculiar principle caseine. So, again, all the suet-puddings, "short-

cake," pie-crust, or pastry, whether baked or boiled, consist simply of farinaceous food rendered stronger nutriment by the addition of fatty matter.

In the same way almost every national dish might be analyzed up to the *pot-au-feu* of our neighbors, the right management of which combines nutritious quality with the abundant aroma and flavor of fresh vegetables which enter so largely into this economical and excellent mess.

It will be apparent that, up to this point, our estimate of the value of these combinations has been limited, or almost so, by their physiological completeness as foods, and by their economical value in relation to the resources of that great majority of all populations, which is poor. But when the inexorable necessity for duly considering economy has been complied with, the next aim is to render food as easily digestible as possible, and agreeable to the senses of taste, smell, and sight.

The hard laborer with simple diet, provided his aliment is complete and fairly well cooked, will suffer little from indigestion. He can not be guilty, for want of means, of eating too much, fertile source of deranged stomach with those who have the means ; physical labor being also in many circumstances the best preventive of dyspepsia. "Live on sixpence a day and earn it," attributed to Abernethy as the sum of his dietary for a gluttonous eater, is a maxim of value, proved by millions. But for the numerous sedentary workers in shops, offices, in business and professions of all kinds, the dish must not only be "complete" ; it must be so prepared as to be easily digestible by most stomachs of moderate power, and it should also be as appetizing and agreeable as circumstances admit.

On questioning the average middle-class Englishman as to the nature of his food, the all but universal answer is, "My living is plain, always roast and boiled"—words which but too clearly indicate the dreary monotony, not to say unwholesomeness, of his daily food ; while they furthermore express his satisfaction, such as it is, that he is no luxurious feeder, and that, in his opinion, he has no right to an indigestion. Joints of beef and mutton, of which we all know the very shape and changeless odors, follow each other with unvarying precision, six roast to one boiled, and have done so ever since he began to keep house some five-and-twenty years ago ! I am not sanguine enough to suppose that this unbroken order which rules the dietary of the great majority of British families of moderate and even of ample means will be disturbed by any suggestions of mine. Nevertheless, in some younger households, where habits followed for want of thought or knowledge have not yet hardened into law, there may be a disposition to adopt a healthier diet and a more grateful variety of aliment. For variety is not to be obtained in the search for new animal food. Often as the lament is heard that some new meat is not

discovered, that the butcher's display of joints offers so small a range for choice, it is not from that source that wholesome and pleasing additions to the table will be obtained.

But our most respectable paterfamilias, addicted to "plain living," might be surprised to learn that the vaunted "roasting" has no longer in his household the same significance it had five-and-twenty years ago; and that probably, during the latter half of that term, he has eaten no roast meat, whatever he may aver to the contrary. Baking, at best in a half-ventilated oven, has long usurped the function of the spit in most houses, thanks to the ingenuity of economical range-makers. And the joint, which formerly turned in a current of fresh air before a well-made fire, is now half stifled in a close atmosphere of its own vapors, very much to the destruction of the characteristic flavor of a roast. This is a smaller defect, however, as regards our present object than that which is involved by the neglect in this country of braising as a mode of cooking animal food. By this process more than mere "stewing" is of course intended. In braising, the meat is just covered with a strong liquor of vegetable and animal juices (*braise* or *mirepoix*) in a closely covered vessel, from which as little evaporation as possible is permitted, and is exposed for a considerable time to a surrounding heat just short of boiling. By this treatment tough, fibrous flesh, whether of poultry or of cattle, or meat unduly fresh, such as can alone be procured during the summer season in towns, is made tender, and is furthermore impregnated with the odors and flavor of fresh vegetables and sweet herbs. Thus, also, meats which are dry, or of little flavor, as veal, become saturated with juices and combined with sapid substances, which render the food succulent and delicious to the palate. Small portions sufficing for a single meal, however small the family, can be so dealt with; and a *réchauffée*, or cold meat for to-morrow, is not a thing of necessity, but only of choice when preferred. Neither time nor space permits me to dwell further on this topic, the object of this paper being rather to furnish suggestions than explicit instruction in detail.

The art of frying is little understood, and the omelet is almost entirely neglected by our countrymen. The products of our frying-pan are often greasy, and therefore for many persons indigestible, the shallow form of the pan being unsuited for the process of boiling in oil, that is, at a heat of nearly 500° Fahr., that of boiling water being 212°. This high temperature produces results which are equivalent indeed to quick roasting, when the article to be cooked is immersed in the boiling fat. Frying, as generally conducted, is rather a combination of broiling, toasting, or scorching; and the use of the deep pan of boiling oil or dripping, which is essential to the right performance of the process, and especially preventing greasiness, is a rare exception and not the rule in ordinary kitchens. Moreover, few English cooks can make a tolerable omelet; and thus one of the most delicious and

nutritious products of culinary art, with the further merit that it can be more rapidly prepared than any other dish, must really at present be regarded as an exotic. Competent instruction at first and a little practice are required, in order to attain a mastery in producing an omelet; but, these given, there is no difficulty in turning out a first-rate specimen. The ability to do this may be so useful in the varied circumstances of travel, etc., that no young man destined for foreign service, or even who lives in chambers, should fail to attain the easily acquired art.—*Nineteenth Century.*

JULIUS ROBERT MAYER.

THE name of the remarkable man whose likeness we give in this number of the "Monthly" is now intimately and imperishably associated with the establishment of the most important scientific truth that has been developed during the last hundred years—the "Conservation of Energy." It is a truth belonging exclusively to no one man, and to no one nation, but to an epoch of scientific advancement that was made by the labors of many distinguished investigators working independently of each other in different countries. In such circumstances it is easy to fall into error in estimating the merits of alleged discoverers. In the first place, there may be very great differences in the positions of men as respects favorable opportunities of making their work known. There is besides less familiarity with what is going on in foreign countries than near by; and there is, moreover, the warping influence of national prejudice by which the claims of men are liable to be exaggerated at home and depreciated abroad. There is undoubtedly less of this bias in science than in any other sphere of intellectual exertion, but this sphere is by no means free from it. It was the fortune of Mayer to suffer from all these causes, and to such a degree that his character as an original discoverer has been denied on very high authority. The ground was strenuously maintained that he had no right whatever to a place among the founders of the great modern doctrine of the "Correlation of Forces." This denial led to investigation and sharp controversy, the result of which was not only to vindicate his claims to be ranked among the discoverers of the new principle, but it was shown that he was probably ahead of all others in grasping and developing it. Now that he has passed away, it is proper to review the subject, which may prove instructive as a chapter of scientific history, as well as interesting in its personal bearing. As we find the investigation thoroughly worked out and most admirably presented in the searching controversy which has now become memorable in the annals of discovery, we shall quote

freely from the materials before us so as to present to our readers as faithfully as possible the considerations on the strength of which the claims of Mayer first became recognized.

As regards the life of Mayer the details are meager. He was born in Heilbronn, Würtemberg, November 25, 1814. He received his early education in the gymnasium of his native town, and studied medicine at Tubingen, finishing his course in Munich and Paris. In 1840 he made a voyage on a Dutch freighter to Java, and spent the summer of that year in professional practice at Batavia. Returning to Heilbronn he first became county wound-physician, and afterward physician to the city, and while giving the main portion of his time to professional labors he devoted himself systematically, and with great assiduity, to original scientific researches on the wide subject of the "Conservation of Forces." In the revolution of 1848 Dr. Mayer took what was called the side of order, which roused against him the antagonism of many of his neighbors. He believed that he had made very important discoveries which were unrecognized and were ascribed to others, while his scientific works were attacked and discredited in a way that preyed upon his feelings and disturbed his mind. This was aggravated by the loss of his children, and he fell into an excited and sleepless condition. Being suddenly seized with a fit of delirium on May 28, 1850, he quitted his bed and leaped from a second-story window, thirty feet high, to the street below. He recovered from the shock, but his mind was so seriously affected that he was sent to a lunatic asylum. Dr. Mülburger, physician to the institution, states that the equilibrium of his mental and emotional nature was seriously affected, one of the symptoms being that, "if you conversed with him about a scientific topic, it was very hard to keep him to the point: his ideas were profound, it is true, surprisingly so, but they came disconnected; they went to the heart of the subject, but they did not hold on to it. He was subject to occasional fits of uncontrollable rage, and on feeling them coming on he would ask to be put in one of the strong cells of the asylum. These fits came on only three or four times during the four months he spent at the asylum, and they did not last long. He had a very strong thirst for spirituous liquors, an inclination which was the result of his mental malady, and the gratification of which increased it." He was at length restored to health, and busied himself with grape culture at Heilbronn. He died in his native town on March 20, 1878, aged sixty-three years.

The following lucid account of Mayer's labors and judicial estimate of his position were made by Professor Tyndall in 1871, and are so admirable that we quote them in full, in preference to anything that it would be possible for us to write:

Dr. Julius Robert Mayer was educated for the medical profession. In the summer of 1840, as he himself informs us, he was at Java, and there observed that the venous blood of some of his patients had a singularly bright red color.

The observation riveted his attention; he reasoned upon it, and came to the conclusion that the brightness of the color was due to the fact that a less amount of oxidation sufficed to keep up the temperature of the body in a hot climate than in a cold one. The darkness of the venous blood he regarded as the visible sign of the energy of the oxidation.

It would be trivial to remark that accidents such as this, appealing to minds prepared for them, have often led to great discoveries. Mayer's attention was thereby drawn to the whole question of animal heat. Lavoisier had ascribed this heat to the oxidation of the food. "One great principle," says Mayer, "of the physiological theory of combustion is, that under all circumstances the same amount of fuel yields, by its perfect combustion, the same amount of heat; that this law holds good even for vital processes; and that hence the living body, notwithstanding all its enigmas and wonders, is incompetent to generate heat out of nothing."

But beyond the power of generating internal heat, the animal organism can also generate heat outside of itself. A blacksmith, for example, by hammering can heat a nail, and a savage by friction can warm wood to its point of ignition. Now, unless we give up the physiological axiom that the living body can not create heat out of nothing, "we are driven," says Mayer, "to the conclusion that it is the *total* heat generated within and *without* that is to be regarded as the true calorific effect of the matter oxidized in the body."

From this, again, he inferred that the heat generated externally must stand in a fixed relation to the work expended in its production. For, supposing the organic processes to remain the same, if it were possible, by the mere alteration of the apparatus, to generate different amounts of heat by the same amount of work, it would follow that the oxidation of the same amount of material would sometimes yield a less, sometimes a greater, quantity of heat. "Hence," says Mayer, "that a fixed relation subsists between heat and work, is a postulate of the physiological theory of combustion."

This is the simple and natural account, given subsequently by Mayer himself, of the course of thought started by his observation in Java. But the conviction once formed, that an unalterable relation subsists between work and heat, it was inevitable that Mayer should seek to express it numerically. It was also inevitable that a mind like his, having raised itself to clearness on this important point, should push forward to consider the relationship of natural forces generally. At the beginning of 1842 his work had made considerable progress; but he had become physician to the town of Heilbronn, and the duties of his profession limited the time which he could devote to purely scientific inquiry. He thought it wise, therefore, to secure himself against accident, and in the spring of 1842 wrote to Liebig, asking him to publish in his "Annalen" a brief preliminary notice of the work then accomplished. Liebig did so, and Dr. Mayer's first paper is contained in the May number of the "Annalen" for 1842.

Mayer had reached his conclusions by reflecting on the complex processes of the living body; but his first step in public was to state definitely the physical principles on which his physiological deductions were to rest. He begins, therefore, with the forces of inorganic nature. He finds in the universe two systems of causes which are not mutually convertible: the different kinds of matter and the different forms of force. The first quality of both he affirms to be *indestructibility*. A force can not become nothing, nor can it arise from nothing. Forces are convertible, but not destructible. In the terminology of his time, he then gives clear expression to the ideas of potential and dynamic energy, illus-

trating his point by a weight resting upon the earth, suspended at a height above the earth, and actually falling to the earth. He next fixes his attention on cases where motion is apparently destroyed, without producing other motion; on the shock of inelastic bodies, for example. Under what form does the vanished motion maintain itself? "Experiment alone," says Mayer, "can help us here." He warms water by stirring it; he refers to the force expended in overcoming friction. Motion in both cases disappears; but heat is generated, and the quantity generated is the equivalent of the motion destroyed. "Our locomotives," he observes with extraordinary sagacity, "may be compared to distilling apparatus: the heat beneath the boiler passes into the motion of the train, and is again deposited as heat in the axles and wheels."

A numerical solution of the relation between heat and work was what Mayer aimed at, and toward the end of his first paper he makes the attempt. It was known that a definite amount of air, in rising one degree in temperature, can take up two different amounts of heat. If its volume be kept constant, it takes up one amount; if its pressure be kept constant, it takes up a different amount. These two amounts are called the specific heat under constant volume and under constant pressure. The ratio of the first to the second is as 1 : 1·421. No man, to my knowledge, prior to Dr. Mayer, penetrated the significance of these two numbers. He first saw that the excess 0·421 was not, as then universally supposed, heat actually lodged in the gas, but heat which had been actually consumed by the gas in expanding against pressure. The amount of work here performed was accurately known, the amount of heat consumed was also accurately known, and from these data Mayer determined the mechanical equivalent of heat. Even in this first paper he is able to direct attention to the enormous discrepancy between the theoretic power of the fuel consumed in steam-engines and their useful effect.

Though this paper contains but the germ of his further labors, I think it may be safely assumed that, as regards the mechanical theory of heat, this obscure Heilbronn physician, in the year 1842, was in advance of all the scientific men of the time.

Having, by the publication of this paper, secured himself against what he calls "Eventualitäten," he devoted every hour of his spare time to his studies, and in 1845 published a memoir which far transcends his first one in weight and fullness, and indeed marks an epoch in the history of science. The title of Mayer's first paper was, "Remarks on the Forces of Inorganic Nature."* The title of his second great essay was, "Organic Motion in its Connection with Nutrition." In it he expands and illustrates the physical principles laid down in his first brief paper. He goes fully through the calculation of the mechanical equivalent of heat. He calculates the performances of steam-engines, and finds that 100 pounds of coal, in a good working engine, produce only the same amount of heat as 95 pounds in an unworking one; the 5 missing pounds having been converted into work. He determines the useful effect of gunpowder, and finds nine per cent. of the force of the consumed charcoal invested on the moving ball. He records observations on the heat generated in water agitated by the pulping-engine of a paper manufactory, and calculates the equivalent of that heat in horse-power. He compares chemical combination with mechanical combination—the union of atoms with the union of falling bodies with the earth. He calculates the velocity with which a body starting at an infinite distance would

* Translations of this and other important papers of Mayer are contained in the volume on the "Correlation of Forces," published by D. Appleton & Co., New York.

strike the earth's surface, and finds that the heat generated by its collision would raise an equal weight of water 17,356° C. in temperature. He then determines the thermal effect which would be produced by the earth itself falling into the sun. So that here, in 1845, we have the germ of that meteoric theory of the sun's heat which Mayer developed with such extraordinary ability three years afterward. He also points to the almost exclusive efficacy of the sun's heat in producing mechanical motions upon the earth, winding up with the profound remark that the heat developed by friction in the wheels of our wind- and water-mills comes from the sun in the form of vibratory motion; while the heat produced by mills driven by tidal action is generated at the expense of the earth's axial rotation.

Having thus, with firm step, passed through the powers of inorganic nature, his next object is to bring his principles to bear upon the phenomena of vegetable and animal life. Wood and coal can burn; whence come their heat, and the work producible by that heat? From the immeasurable reservoir of the sun. Nature has proposed to herself the task of storing up the light which streams earthward from the sun, and of casting into a permanent form the most fugitive of all powers. To this end she has overspread the earth with organisms which, while living, take in the solar light, and by its consumption generate forces of another kind. These organisms are plants. The vegetable world, indeed, constitutes the instrument whereby the wave-motion of the sun is changed into the rigid form of chemical tension, and thus prepared for future use. With this prevision, as will subsequently be shown, the existence of the human race itself is inseparably connected. It is to be observed that Mayer's utterances are far from being anticipated by vague statements regarding the "stimulus" of light, or regarding coal as "bottled sunlight." He first saw the full meaning of De Saussure's observation as to the reducing power of the solar rays, and gave that observation its proper place in the doctrine of conservation. In the leaves of a tree, the carbon and oxygen of carbonic acid, and the hydrogen and oxygen of water, are forced asunder at the expense of the sun, and the amount of power thus sacrificed is accurately restored by the combustion of the tree. The heat and work potential in our coal strata are so much strength withdrawn from the sun of former ages. Mayer lays the axe to the root of the notions regarding "vital force" which were prevalent when he wrote. With the plain fact before us that in the absence of the solar rays plants can not perform the work of reduction, or generate chemical tensions, "it is," he contends, "incredible that these tensions should be caused by the mystic play of the vital force." Such an hypothesis would cut off all investigation; it would land us in a chaos of unbridled phantasy. "I count," he says, "therefore, upon your agreement with me when I state, as an axiomatic truth, that during vital processes the *conversion* only, and never the *creation* of matter or force, occurs."

Having cleared his way through the vegetable world, as he had previously done through inorganic nature, Mayer passes on to the other organic kingdom. The physical forces collected by plants become the property of animals. Animals consume vegetables, and cause them to reunite with the atmospheric oxygen. Animal heat is thus produced; and not only animal heat, but animal motion. There is no indistinctness about Mayer here; he grasps his subject in all its details, and reduces to figures the concomitants of muscular action. A bowler who imparts to an eight-pound ball a velocity of thirty feet, consumes in the act one-tenth of a grain of carbon. A man weighing 150 pounds, who lifts his own body to a height of eight feet, consumes in the act one grain of

carbon. In climbing a mountain 10,000 feet high, the consumption of the same man would be two ounces, four drachms, fifty grains of carbon. Boussingault had determined experimentally the addition to be made to the food of horses when actively working, and Liebig had determined the addition to be made to the food of men. Employing the mechanical equivalent of heat, which he had previously calculated, Mayer proves the additional food to be amply sufficient to cover the increased oxidation.

But he does not content himself with showing, in a general way, that the human body burns according to definite laws, when it performs mechanical work. He seeks to determine the particular portion of the body consumed, and in doing so executes some noteworthy calculations. The muscles of a laborer 150 pounds in weight weigh 64 pounds; but, when perfectly desiccated, they fall to 15 pounds. Were the oxidation corresponding to that laborer's work exerted on the muscles alone, they would be utterly consumed in eighty days. The heart furnishes a still more striking example. Were the oxidation necessary to sustain the heart's action exerted upon its own tissue, it would be utterly consumed in eight days. And, if we confine our attention to the two ventricles, their action would be sufficient to consume the associated muscular tissue in three and a half days. Here, in his own words, emphasized in his own way, is Mayer's pregnant conclusion from these calculations: "The muscle is only the apparatus by means of which the conversion of the force is effected; *but it is not the substance consumed in the production of the mechanical effect.*" He calls the blood "the oil of the lamp of life"; it is the slow-burning fluid whose chemical force, in the furnace of the capillaries, is sacrificed to produce animal motion. This was Mayer's conclusion twenty-six years ago. It was in complete opposition to the scientific conclusions of his time; but eminent investigators have since amply verified it.

Thus, in baldest outline, I have sought to give some notion of the first half of this marvelous essay. The second half is so exclusively physiological that I do not wish to meddle with it. I will only add the illustration employed by Mayer to explain the action of the nerves upon the muscles. As an engineer, by the motion of his finger in opening a valve or loosing a detent, can liberate an amount of mechanical motion almost infinite compared with its exciting cause, so the nerves, acting upon the muscles, can unlock an amount of activity wholly out of proportion to the work done by the nerves themselves.

As regards these questions of weightiest import to the science of physiology, Dr. Mayer, in 1845, was assuredly far in advance of all living men.

Mayer grasped the mechanical theory of heat with commanding power, illustrating it and applying it in the most diverse domains. He began, as we have seen, with physical principles; he determined the numerical relation between heat and work; he revealed the source of the energies of the vegetable world, and showed the relationship of the heat of our fires to solar heat. He followed the energies which were potential in the vegetable, up to their local exhaustion in the animal. But in 1845 a new thought was forced upon him by his calculations. He then, for the first time, drew attention to the astounding amount of heat generated by gravity where the force has sufficient distance to act through. He proved, as I have before stated, the heat of collision of a body falling from an infinite distance to the earth, to be sufficient to raise the temperature of a quantity of water, equal to the falling body in weight, 17,356° C. He also found, in 1845, that the gravitating force between the earth and sun was competent to generate an amount of heat equal to that obtainable from the combustion of

six thousand times the weight of the earth of solid coal. With the quickness of genius he saw that we had here a power sufficient to produce the enormous temperature of the sun, and also to account for the primal molten condition of our own planet. Mayer shows the utter inadequacy of chemical forces, as we know them, to produce or maintain the solar temperature. He shows that were the sun a lump of coal it would be utterly consumed in five thousand years. He shows the difficulties attending the assumption that the sun is a cooling body; for, supposing it to possess even the high specific heat of water, its temperature would fall 15,000° in five thousand years. He finally concludes that the light and heat of the sun are maintained by the constant impact of meteoric matter. I never ventured an opinion as to the truth of this theory; that is a question which may still have to be fought out. But I refer to it as an illustration of the force of genius with which Mayer followed the mechanical theory of heat through all its applications. Whether the meteoric theory be a matter of fact or not, with him abides the honor of proving to demonstration that the light and heat of suns and stars *may* be originated and maintained by the collisions of cold planetary matter.

Let us now go back ten years and see how this verdict was arrived at.

When Professor Tyndall was preparing his work on heat, he desired to acquaint himself with all that Mayer had done upon this subject. He accordingly wrote to two eminent Germans, authorities upon this question, for information. Both responded, and one of them, Professor Clausius, procured Mayer's publications to send to Tyndall. In his first letter he said he thought Professor Tyndall would not find anything very important in Mayer's writings. But before forwarding the memoirs he read them himself, and then wrote to Tyndall: "I must here retract the statement, in my last letter, that you would not find much matter of importance in Mayer's writings; I am astonished at the multitude of beautiful and correct thoughts which they contain." He then went on to point out various important subjects in the treatment of which Mayer had anticipated other eminent writers. Professor Tyndall perfectly agreed with Clausius, and resolved to do his share toward making so able and original a man better known in England. Accordingly, on June 6, 1862, he gave a most interesting lecture at the Royal Institution, full of new views and novel experiments, on the subject of "Force." At its close he remarked: "To whom, then, are we indebted for the striking generalizations of this evening's discourse? All that I have laid before you is the work of a man of whom you have scarcely ever heard. All that I have brought before you has been taken from the labors of a German physician, named Mayer. Without external stimulus, and pursuing his profession as town physician in Heilbronn, this man was the first to raise the conception of the interaction of natural forces to clearness in his own mind. And yet he is scarcely ever heard of in scientific lectures, and even to scientific men his merits are but partially known. Led by his own beautiful researches, and quite independent of Mayer, Mr. Joule published his

first paper on the 'Mechanical Value of Heat,' in 1843; but in 1842 Mayer had actually calculated the mechanical equivalent of heat from data which a man of rare originality alone could turn to account. From the velocity of sound in air, Mayer determined the mechanical equivalent of heat."

In October of the same year there appeared an article in "Good Words," under the title of "Energy," the joint production of Professors Thomson and Tait, which was called forth by Tyndall's June lecture on "Force." In this paper and in subsequent ones, defending it, the writers confess themselves startled at the recent attempt made "to place Mayer in a position which he never claimed," and they deny to him "the credit of being the first to establish in its generality the principle of the 'Conservation of Energy,'" and assert that "Mayer's paper (1842) has *no claims to novelty or correctness at all*, saving this, that by a lucky chance he got an approximation to a true result from *an utterly false analogy*"; and that "even on this point he had been anticipated by Séguin, who three years before the appearance of Mayer's paper had obtained and published the same numerical result from the same hypothesis." They claim that the honors of producing this theory are English throughout; that Newton, Rumford, and Davy established it, and that Dr. Joule, of Manchester, developed and matured it; and, impelled by a proper "scientific patriotism," they protest against this attempt of Tyndall to make over to a foreigner what belongs to his own countrymen, and is withheld by depreciation and suppression.

These positions were met and the whole case of Professors Thomson and Tait exploded in a series of communications addressed by Professor Tyndall to the "Philosophical Magazine." As to the statement that Mayer himself did not claim to be a founder of the "Dynamical Theory of Heat," Professor Tyndall quoted the following passage from a publication of Mayer's in 1851: "The new subject" (the mechanical theory of heat) "soon began to excite the attention of learned men, but, inasmuch as both at home and abroad the subject has been exclusively treated as a foreign discovery, I find myself compelled to make the claims to which priority entitles me; for, although the few investigations which I have given to the public, and which have almost disappeared in the flood of communications which every day sends forth, without leaving a trace behind, prove by the very form of their publication that I am not one who hankers after effect, it is not therefore to be assumed that I am willing to be deprived of intellectual property which documentary evidence proves to be mine."

As to the declaration that Mayer's views of 1842 had no novelty or correctness at all, save what he luckily blundered into, Professor Tyndall first quotes some counter-authorities. In Professor Helmholtz's celebrated discourse, delivered at Königsberg, in 1854, on the interaction of natural forces, this great physicist remarks, "The first man who

correctly perceived and rightly enunciated the general law of nature which we are here considering was a German physician, J. R. Mayer, of Heilbronn, in the year 1842." Again, M. Verdet, an eminent French authority, especially in the literature of science, in addressing the Chemical Society of Paris on the mechanical theory of heat in 1862, remarked: "I now come to the researches which, from 1842 to 1849, definitely founded the science. These researches are the exclusive work of three men * who, without concert and without knowing each other, arrived simultaneously in almost the same manner at the same ideas. The priority in the order of publication belongs, without any doubt, to the German physician, Jules Robert Mayer, whose name has occurred so often in these lectures; and it is interesting to know that it was by reflecting on certain observations in his medical practice that he perceived the necessity of an equivalence between work and heat. . . . He perceived in the act of respiration the origin of the motive power of animals; and the comparison of animals with thermic engines afterward suggested to him the important principle with which his name will be connected for ever. . . . We also find in the same memoir (1842) a first determination of the mechanical equivalent of heat deduced from the properties of gases, which is perfectly exact in principle."

How Dr. Mayer arrived at the mechanical equivalent of heat, has been briefly referred to by Tyndall in a previous quotation. It will not be possible here to go into the full detail of Mayer's method, but the reader who is curious about it may consult Tyndall's "Heat as a Mode of Motion" for a clear statement, and, for a still completer account, vol. xxviii. of the "Philosophical Magazine," Fourth Series, page 25. Before they had become familiar with Dr. Mayer's work, Professors Thomson and Tait had no word for him but that of disparagement; but, as his results were forced upon their attention, they were compelled to concede something to him, and so Tait admits, in 1863, that "Mayer's later papers are extremely remarkable and excessively interesting, and certainly deserve high credit." Yet his claim as the first to determine the mechanical equivalent of heat is still pointedly denied. Indeed, Professor Tyndall himself does not lay the highest stress upon this achievement of Dr. Mayer. He observes: "I must here say distinctly that I would not for an instant allow my estimate of Mayer to depend upon his determination of the mechanical equivalent of heat. It is the insight which he had obtained in advance of all other men regarding the relationship of the general energies of the universe, as illustrated in the whole of his writings, that gives him his claim to my esteem and admiration."

Now, undoubtedly the whole is greater than a part, and Mayer's fame has a far broader foundation than any one special result could afford. But we think that his determination of the mechanical equiv-

* Mayer, Colding, and Joule.

alent of heat, in the year 1842, with the resources he had, and the exactness which he attained, is one of the most marvelous exploits in the whole history of science, is incomparably his greatest achievement, and is sufficient alone to place him in advance of all the thinkers who have devoted themselves to this great research. And we apprehend that this would have long ago been conceded but for the rival claims of Dr. Joule to this discovery. It is admitted on all hands, and even by Mayer himself, that Joule's laboratory processes were necessary and invaluable in completing the work, and placing this truth upon its firm and experimental basis. With great patience and skill he worked out the law of the mechanical equivalence of heat, as a demonstration that all men can verify, and, by the award of the whole scientific world, that law is permanently connected with his name. But Joule's results were reached only in 1849, while Mayer had arrived at the same result by other methods in 1842. What was it that both men were driving at? It was the working out of a great relation, or the establishment of a universal truth of nature. Mayer reached it, by using the data that science had created for him. He got it first, he got it independently, and he got it exactly, or within a small fraction of the expression arrived at by Joule after six years of subsequent experiment. Mayer was the pioneer, the revealer, the creator of the theory, and Joule the verifier of his work. That verification was required and has made the name of Joule immortal; but who will compare it with that master stroke of genius by which from scanty materials the great truth was first independently seized and formulated? In 1849 Dr. Joule fixed the exact mechanical equivalent of heat after many laborious experiments, at 772 foot-pounds. Seven years previously Dr. Mayer pursued a method which gave the mechanical equivalent of heat as 771·4 foot-pounds.

It was alleged by Thomson and Tait, as we have seen, that Mayer's method had been adopted by the Frenchman Séguin, three years earlier, and that he anticipated the German in deducing the mechanical equivalent of heat. Séguin, in 1839, published a work on the steam-engine, in Paris; and that work contains a table on the relations of pressures, temperatures, and mechanical effects of steam, from which it was alleged that the mechanical equivalent of heat may be inferred. But the widest discrepancies existed among the interpretations of these tables by different authorities. Upon a careful investigation of the subject Professor Tyndall found that Séguin's and Mayer's numerical results did not refer to the same things at all, and that Séguin's tables did not attempt to give the mechanical equivalent of heat. Professor Tyndall says: "It is only necessary, however, to read the foregoing pages to see that Mayer and Séguin are speaking of two totally different things; that the degrees of the one are not the degrees of the other; that the 'temperatures correspondantes' of the latter, which refer to his compressed steam, are not thermal units at all, and

that there is no determination whatever of the mechanical equivalent of heat in the above table."

We have no space to go further into the particulars of this controversy, which was as discreditable to the assailants of Mayer as it was honorable to his disinterested defender. It is to be remembered that on all occasions, and in the most emphatic way, Professor Tyndall bore his testimony to the greatness of Dr. Joule's work, and deprecated every construction of his efforts which assumed that he was exalting the German at the expense of the Englishman. His demand was that Dr. Mayer be accorded a distinguished place among the founders of the modern doctrine of forces—such a place as he was incontestably entitled to by the scope, originality, and earliness of his work. But his opponents would allow the German doctor no merit whatever as a pioneer or discoverer, and no place in the circle of eminent men who created the new epoch of dynamical philosophy. The attack, however, upon Mayer signally failed of its intended purpose, and the parties who made it had the mortification of seeing that their ungenerous exertions were overruled to an end very different from that which they had designed. After the sifting and probing which followed the onslaught of the Scotchmen, the claims in behalf of Mayer were universally recognized as just; he was chosen by acclamation a member of the French Academy of Sciences, and the award of the Copley medal in 1871, the highest honor in the gift of the Royal Society of England, was the sharp rebuke of British Science to the unworthy efforts incited by a spurious patriotism to depreciate an illustrious foreign *savant.*

Dr. Mayer, as we have intimated, was a man of much suffering, which was undoubtedly aggravated by the neglect and injustice with which his labors were treated; and, when generous recognition of his services was made, the good effect on his disordered mind was palpable. It was while he was in the asylum, under treatment, that the Copley medal with Tyndall's accompanying letter was put into his hands. Dr. Mülburger, the attending physician, remarked, "I can still see him as he entered my room, beaming with gladness, to exhibit to me this rare distinction."

A monument is to be erected to Mayer at Heilbronn, and the scientific men of different countries are adding their contributions to those of his townsmen for the purpose of its erection.

CORRESPONDENCE.

LETTER FROM MR. KIDDLE.

To the Editor of the Popular Science Monthly.

THERE seems to be nothing so capable of throwing a "scientist" into a paroxysm of rage as the serious attempt to talk to him of *spirit*, *spirit-world*, "*spiritual body*," etc. In the words of Brewster, "*spirit* is the last thing he will give in to"; or, to put it in Huxley's mild way, "supposing the phenomena to be genuine, *they do not interest me*." One might suppose that men whose habits of mind are the offspring of careful investigation and calm inquiry, would take any class of phenomena, and at least contemplate them with *scientific* patience, keeping their minds poised and ready to receive more light. But no; some favorite hypothesis seems to be in danger, and our modern philosopher, who either claims the paternity of it, or hangs to the skirts of him thus highly honored, has always a choice assortment of literary missiles to hurl at the trespasser. When a man feels that he can not meet another in fair argument, he usually greets him with such choice epithets as *fool*, *driveling idiot*, *lunatic*, etc., etc. How scientific! How worthy of a scientific journal is such mean and cheap scurrility!

Such is the temper in which you have chosen to assail me and my recently published book, "Spiritual Communications," in the June number of "The Monthly." Of course, I can not contend with you in throwing mud; your vocabulary of abuse is richer and stronger than any I could possibly command; and I acknowledge, therefore, that you have the advantage of me in this respect; but let me suggest to you that one who claims to be a scientist should resort to the weapons of logic, not the bludgeon of a ruffian. Nor was even this brutal treatment sufficient to satisfy your scientific instincts. You seemed to think your literary crucifixion would be incomplete unless you brought a murderer to share my fate; but remember that the greatest being that ever walked upon the surface of this planet was crucified between two thieves; and remember, too, who did it. "Woe unto the world because of offenses, but woe unto that man by whom the offense cometh!" Your article does, indeed, show the "survival of savagery."

The editor of this book may, indeed, claim some consideration for accredited ability to investigate phenomena brought to his notice, as well as yourself. What right have you, who know nothing of the facts—and will not listen to the evidence on which they rest—to abuse me for stating them, simply because they do not fit into your notions, your conceits, and your theories? The man who refuses to investigate, or listen to the results of investigation — who shuts his eyes against the sun of truth, and angrily protests there is no sun—he is the idiot; or, if he continues in that course, will soon become one. If you had read my book, you would have seen that, instead of setting aside all other spiritual revelations, that which is offered in the book strengthens and confirms the divine revelation of the Scriptures, and is presented in that relation to it; but it adds to it, and makes clear many things previously left in obscurity. Jesus said (John xvi. 12): "I have yet many things to say unto you, but ye can not bear them now." Science is constantly giving birth to new theories, as you yourself very well know. What, for example, is the science of chemistry now, compared to what it was when you first called at my school with your chart of its nomenclature? Why, then, should you quarrel with revelation if God chooses to expand it, and give us a little more spiritual light? Is your soul (excuse me, your *mind*) so bathed with heavenly radiance that you are afraid any addition to it will blind you?

Still, there is one part of your article on *savagery* that gives me real pleasure. You appear to be anxious for the integrity of "spiritual revelation." It does really appear as if you could look beyond the universe of matter to the far greater supersensuous world of God's creation. I congratulate you and the world upon this heavenly change. Who knows but the millennium may be at hand, when the lion will lie down with the lamb (outside of him), and the editor of "The Popular Science Monthly" will be able to read "Spiritual Communications" without losing his philosophic temper, and without becoming lost to all sense of scientific and literary decency?

I commend to you, in conclusion, the words of Mr. Parke Godwin, which you are, doubtless, able to recall: "Let us be assured that some truth has come a good while ago, that it is coming still, in many ways, and will come in broader and rosier flashes in the future, though not to him who, ostrich-like, buries his head in the sand, or muffles his eyes against any of its illuminations."

I have the honor to subscribe myself,

Very sincerely your friend,

HENRY KIDDLE.

NEW YORK, *June* 5, 1879.

LETTER FROM MR. BERGH.

To the Editors of the Popular Science Monthly.

On page 637 of your September edition, there is an article entitled "Death to the English Sparrow," which refers to a communication in the "American Naturalist," written by one Dr. Elliott Coues, recommending the extermination of that pretty little creation of the Almighty, and suggesting that boys be constituted their executioners.

Who this enemy to God, through one of his works, is, I know not—whether he be a Zulu or an American savage, I care not; but, since he has been permitted a space in two of our leading menstruals, out of deference to them, I have thought proper to notice the barbarism of the sentiment uttered by him.

This man dares to rebuke the Maker of all things, by calling the innocent little being "a wretched interloper," which has no place in the "natural economy of this country"; and he betrays his own place in the social and professional world by characterizing all who think otherwise as "silly old fogies," "*quasi*-ornithologists," and "*claqueurs* of the *quasis*."

This person, who thus arraigns his Creator, and attributes human fallibility to the Infinite, belongs, it seems, to a profession which should purge itself of a fellow who has not the brains to comprehend the meaning of humanity and good policy, nor yet the fact that God has not created anything needlessly—not even Elliott Coues.

This inverted genius suggests the policy of founding a school wherein boys may be educated in the practice of murder, which of course includes all other social crimes.

It is true, he does not advise these boys to begin by killing their parents, or other human beings, but to commence with an innocent little bird; when, after an apprenticeship of a few years, he presumes they will be prepared to do the heavy business of throat-cutting, stabbing, and shooting.

This wonderful individual, when he conceived this grandest idea of his life, doubtless had in his mind "the physical fact"—as the Honorable Mr. Sloate would say—that there is a beginning to everything; that the mighty Mississippi at its source is but a tiny stream, and hence his pupils in time would graduate from his college with all the honors enjoyed by the most distinguished students of crime that have ended their days upon the scaffold.

But the refreshing tenderness of this medical practitioner—whom possibly some innocent invalid may have unwittingly called to his bedside—is best expressed by himself. He says: "Let the birds shift for themselves; take down the boxes and all special contrivances for sheltering and petting the sparrows; stop feeding them; stop supplying them with building material; abolish the legal penalties for killing them; let boys kill them; let them be trapped and used as pigeons, or glass balls in shooting-matches among sportsmen"!

It is said that the inventor of the guillotine was the first person to perish by it. O that this modern Æsculapius would only introduce his beautiful theory among us here in New York—for he is a resident of a much-to-be-envied Eastern State—so that the undersigned might profit by the opportunity of making him acquainted with the legal guillotine which he would certainly be compelled to ascend! Henry Bergh.

REMARKABLE LIGHTNING-STROKE.

To the Editors of the Popular Science Monthly.

There recently occurred in our city a case of stroke by lightning which, no doubt, from its strange freaks, will be of interest to the readers of The Popular Science Monthly. It took place in a grocery-store, and two persons were the sufferers. The bolt, after tearing up the eaves of the house, entered it on the side, leaving a smutty stain between the cracks. It bulged out the side of the shop for several feet, put out the lamp, knocked down many articles from the shelves, took off the tops of several lamp-chimneys resting on them, completely tore off the paper wrappers of many small cakes of soap, and finally emerged at the corner of the room, tearing off several planks. In the passage of the current from one division of the shelves to the other, it either split the dividing boards or passed under them, partially fusing the nails and charring the adjacent wood. But what makes the stroke most remarkable is the way in which it affected the two men who were struck. One of them, Ware, was stunned for a few moments, had his pipe knocked from his mouth several feet away, and was left with a red, sore scar across his cheek and a paralysis of his arms, which latter remained for about two hours. Still more strangely did it deal with the other man, Bullard, who was resting upon the show-case opposite Ware. The current passed up his arm, under the armpit, down the right side of the body to the thigh, leaped across to the inner side of the left leg, and passed down the leg to the foot. It made a red bunch and sore mark upon the body, singed the hair from both legs, and left the sufferer unconscious for more than twenty-four hours. Both have fully recovered, with the exception of a little soreness. In both cases we noted the spiral direction of the current. The house was low, in a depressed situation, and protected with a rod. Robert F. Jackson, Jr.

Macon, Georgia, *May* 20, 1879.

PYTHAGORAS ON BEANS.

To the Editors of the Popular Science Monthly.

DEAR SIRS: Allow me to give expression to some thoughts suggested by reading the interesting article of Dr. Felix Oswald, in the April number of your publication. The author commits an error when he ascribes the forbidding, by Pythagoras, of using beans as an article of food to a deprecating view of it; it was just the opposite view that caused him to do so. I have before me an essay, "Pythagoras, the Sage of Samos," according to the latest researches, written by Eduard Baltzer (in German), who draws mainly on the "History of Philosophy," by Professor Roeth, of Heidelberg. Baltzer's work is the most successful of the different endeavors made to furnish, from the few fragments that have remained of his works, a biography of the greatest of ancient thinkers, the father of philosophy, as he has been truly called. Beans were forbidden for the common use of his followers, as they were considered a specially sacred article, and were only eaten at certain meals that formed a part of the Pythagorean *cultus*, the so-called Orphic mysteries.

The fundamental truth of preparing the body by a pure diet and pure physical habits for the growth of spiritual life, that formed the basis for all the doctrines of the ancient philosophers, and that has found the most distinct expression in the words of St. Paul, "Know ye not that ye are the temple of God, and that the spirit of God dwelleth in you?" etc., has become utterly darkened to the modern perception in its clumsy materialistic tendency—the very rudiments of instinct, the organic perception of the laws of nature underlying its structure, have been lost or utterly distorted by the wrong habits of a carnivorous race; and the modern man, with all his vaunted scientific acquirements, will yet have to go begging to antiquity to gather some crumbs of wisdom and truth. As the earth receives the effects of solar radiation, the source of all its organized physical life, only after it has been modified and polarized by its atmospheric medium—whereby the solar energy assumes, as it were, a geomorphous condition—just so all spiritual perception in the human mind becomes anthropomorphized, individually as well as generically, by the physical condition of the body; and the clear-eyed observer recognizes the cause of mental and moral anomalies in the condition of the physical postulates. Pessimism, as it seems to spread like a frightening nightmare through the race, is nothing but a spiritual perception, polarized to distortion by a bodily medium poisoned by tobacco and alcohol; and every one suffering from it can cure himself and become an optimist by adopting a pure Pythagorean diet, and thus armored draw truth from the wells of divine revelation. I feel free to say so, because, for the sake of experiment, I have changed myself backward and forward severally out of one state of mind into the other.

Returning to our beans, I find that there is no article of food equal to them for gaining the physical postulate for a higher spiritual soul-life. Wheat may be rightly called the best brain-food—next to wheat probably barley, but receiving a greater share of direct sunlight than the beans, which are surrounded by a thicker husk or hull than the grain; whereas the latter, receiving a greater share of indirect radiation through their larger leaves, the grain possesses a more positive vital polarity in its nutritive influence, and the bean a more negative one, whereby the former favors subjective, active, intellectual effort, and the latter predisposes to objective intellectual receptivity, the requirement for spiritual perception.

The New-Englanders, who may be called, I suppose, the salt of the American nation, in establishing baked beans as a national dish, have furnished a proof of the absolute wisdom manifested in the mysterious operations of the unconscious in human nature, as a modern pessimistic philosopher chooses to call the result of divine guidance in the inner life of man.

Respectfully, JULIUS ASHMAN.

NEW YORK, *April* 4, 1879.

EDITOR'S TABLE.

EXPLANATIONS THAT DO NOT EXPLAIN.

THERE is a certain class of minds whose efforts to explain things generally leave them more obscure than they were before. In undertaking to represent a question they complicate rather than simplify it, and instead of helping the learner to understand a subject they hinder him. This failure to make things lucid and comprehensible is due to various causes. Oftenest, it comes from a total neglect of the art of luminous writing, and it is unfortunate that many scientific men are not a little perverse about cultivating this art. They do not, as a matter of conscience,

make any effort to enter into the state of mind of the parties addressed, and their expositions, therefore, often fail from lack of adaptation. Sometimes a subject familiar to teachers of great capacity is still too abstruse to be grasped by common minds. Sometimes the expounder does not understand the subject himself; and not unfrequently hypotheses are invented to explain unexplainable things, and which serve only to increase existing difficulties. A marked illustration of this is afforded by a lecture delivered not long ago before the Royal Institution, by the eminent physicist and mathematician, Sir William Thomson, who announced as his topic of discourse the curious subject, "Maxwell's Sorting Demons."

The lecture was mainly devoted to an explication of the phenomena of the diffusion of liquids and the principles it involves. Professor Thomson had many tubes prepared, each containing two liquids of different colors, to represent the progress of diffusion, while some ingenious experiments were made by throwing the spectra of various solutions upon the screen with an electric light. The diffusibility of solids and gases was also referred to, and a just tribute paid to the memory of Graham, whose name stands most prominently associated with this branch of research.

Sir William Thomson's reasons, however, for bringing forward these phenomena of diffusion were that they stand very closely related to the present theories and speculations concerning the molecules of matter, and which aim to account for their motions. In diffusion, the molecules gradually intermingle, according to definite laws, which are variable in different cases. The molecules do not move capriciously or irregularly, as all chemical action and all crystallization prove. But why do they move this way or that, and why always go the same way in the same conditions? This "why" is the perplexing word of science, and when we get down among objects the very existence of which is hypothetical it carries us far beyond our depth. But Professor Maxwell thinks he gives us aid here by inventing a host of little demons—living creatures with wills and infallible intelligence—which sort the molecules and regulate their extraordinary motions. In a very brief abstract of his lecture which Sir William Thomson has published, he thus explains the attributes and offices of these remarkable agents:

> Clerk Maxwell's "demon" is a creature of imagination having certain perfectly well-defined powers of action, purely mechanical in their character, invented to help us to understand the "dissipation of energy" in nature. He is a being with no preternatural qualities, and differs from real living animals only in extreme smallness and agility. He can at pleasure stop, or strike, or push, or pull any single atom of matter, and so moderate its natural course of motion. Endowed ideally with arms and hands and fingers—two hands and ten fingers suffice—he can do as much for atoms as a piano-forte player can do for the keys of the piano—just a little more, he can push or pull each atom *in any direction.*
>
> He can not create or annul energy; but, just as a living animal does, he can store up limited quantities of energy, and reproduce them at will. By operating selectively on individual atoms he can reverse the natural dissipation of energy, can cause one half of a closed jar of air, or of a bar of iron, to become glowingly hot and the other ice cold; can direct the energy of the moving molecules of a basin of water to throw the water up to a height and leave it there proportionately cooled (1° Fahr. for seven hundred and seventy-two feet of ascent); can "sort" the molecules in a solution of salt or in a mixture of two gases, so as to reverse the natural process of diffusion, and produce concentration of the solution in one portion of the water, leaving pure water in the remainder of the space occupied; or, in the other case, separate the gases into different parts of the containing vessel.
>
> The classification, according to which the ideal demon is to sort them, may be according to the essential character of the atom: for instance, all atoms of hydrogen to be let go to the left, or stopped from crossing to

the right, across an ideal boundary; or it may be according to the velocity each atom chances to have when it approaches the boundary: if greater than a certain stated amount, it is to go the right; if less, to the left. This latter rule of assortment, carried into execution by the demon, disequalizes temperature, and undoes the natural diffusion of heat; the former undoes the natural diffusion of matter.

This looks to us like a somewhat ridiculous way of evading the real difficulties in the explanation of molecular motions and their effects. All nature is supposed to be filled with infinite swarms of absurd little microscopic imps, which are so omniscient that they direct the invisible and insensible movements by which the whole order of nature is determined and maintained. When men like Maxwell, of Cambridge, and Thomson, of Glasgow, lend their sanction to such a crude hypothetical fancy as that of little devils knocking and kicking the atoms this way and that, in order to explain the observed changes of natural phenomena, we may well ask, What next? This is a palpable case of contriving an artifice to explain a subject which yet leaves the subject more obscure than ever. There were difficulties enough with the molecules considered alone, but when complicated with another hypothetical order of beings the difficulties are redoubled, for we have now to explain the explanation. There is a great proneness to invent explanations which only remove the trouble one step further away. Sir William Thomson's hypothesis of the origin of terrestrial life by means of germs, brought to our planet from some unknown source by meteorites, is another example of explanations by assumptions, in which nothing is explained. There is a class ot scientific men who feel it incumbent upon them to answer all questions. They do not seem to appreciate the fact that there are limits to our knowing, which had better be honestly acknowledged, instead of offering conjectures which are mere travesties of legitimate theory, and absurdities in science.

MR. BERGH AND THE SPARROWS.

We print an indignant letter from Mr. Bergh the philanthropist, denouncing one of our eminent ornithologists for saying that the English sparrows among us are interlopers, and, instead of being protected, should be left to shift for themselves, and be exposed to the raids of the street boys. We have a very high respect for Mr. Bergh and his mission, and have never been disposed to criticise his peculiarities or find fault with the way in which he has chosen to perform his duty. It is enough that such a man was greatly needed in the community, and it is not well to raise questions of taste, or to carp at mistakes committed in the performance of a disagreeable but most beneficent public service. We cordially approve of his practical work in protecting animals against the infliction of cruelty, whether from wantonness, carelessness, or insensate stupidity. But because Mr. Bergh's labors are important they ought to be maintained on proper grounds; though, judging from his letter, we should rather trust his instincts than his logic.

As regards the sparrows, Mr. Bergh seems not to recognize that they are at present under indictment, and, while we have no disposition to prejudge their case, it certainly is not to be settled on purely sentimental grounds. The question of their treatment depends upon whether or not they have become pests and nuisances. If it is true, as maintained by reputable naturalists and those who have observed their habits and history, that these birds are extremely prolific, hatching out several broods in the same season, and that, besides this, they have been so coddled and cared for as greatly to

increase the usual rate of their multiplication; if it is true that they are quarrelsome and pugnacious little creatures, and by their bad dispositions and excessive numbers are driving out other birds, and consuming the means of subsistence, which all should share, and, moreover, if they are specially destructive to buds, fruits, and grains, as is also alleged, so that on the whole they may do a great deal more mischief than good — then it is just as proper to destroy them as to destroy any other pests. If such is their character, protection should be withdrawn from them, and they should be exterminated in all suitable ways. Mr. Bergh ought to have addressed himself to these considerations, and shown if he can that the charges against the sparrows are false, and that they are entitled to all the favors they get.

But he puts the case on different grounds. He objects to the killing of his pets for teleological reasons—that is, because it thwarts the purposes of Divine Beneficence, and, by the prominence he gives to this notion in his letter, we must assume that he regards it as imperative. He looks upon Dr. Coues as a man who would exterminate one of the "pretty little creatures of the Almighty," and that he is therefore an "enemy of God"; and Mr. Bergh expresses a somewhat sanguinary wish that he could get hold of him, and subject him to the guillotine of New York law.

Now, there is something wrong here. Whenever one party wants to give another party the law in the name of God, the matter requires looking into. Mr. Bergh assumes to know the Divine intentions: does he probably understand much more about them than his neighbors? He seems somewhat reckless in his mental movements, but is he not aware that the water hereabouts is very deep? He plays off theology upon Dr. Coues, but we suspect that the naturalist might give the philanthropist large odds, and still beat him at the game.

For when Mr. Bergh says to Dr. Coues, "You would let loose the street boys upon the sparrows, and are therefore an enemy of God," Dr. Coues may reply: "How do you know that the propensities of boys are not among the divinely appointed means of dealing with sparrows? And if it is a question of Divine purposes, who created the sparrow-hawk—the most destructive little savage ever set free in the sky? If you wish some pointed information regarding the intentions of the Almighty in respect to the treatment of sparrows, consult the excellent volume on birds by the Rev. J. G. Wood, page 85."

Should Mr. Bergh see fit to comply with the suggestion, he will there find that sparrow-hawks for some purpose have been provided on a very large scale, being plentifully found in all quarters of the world. That it may do its work of destruction effectually, the sparrow-hawk was made one of the most vicious, sanguinary, and cruel of all birds of prey. Usually very wild, shy, and wary, it is difficult of approach, except when "hovering about a flock of sparrows," and then "the ardor of its destructive propensities is so great that all its faculties seem to be absorbed in the gratification of the ruling passion, so that it is evidently unmindful of anything but its flying prey. A sparrow-hawk has even been known to dash furiously at a man, who endeavored to rescue a small bird which it attacked."

Hawks, as is generally known, are capable of being domesticated and trained to hunt as in the art of falconry; but the sparrow-hawk is so fierce and untamable that it is the worst of all its tribe for this purpose. It is indeed courageous, and will dash at any quarry that may be pointed out to it, but it is crabbed, intractable, and so treacherous that it can not be trusted. Besides, it "is so quarrelsome that if

several of these birds should be fastened to the same perch or placed in the same cage they will certainly fight each other, and in all probability the conqueror will eat his vanquished foe! Such an event has actually occurred, the victrix—for it was a female—killing and devouring her intended spouse." A naturalist, writing in the "Field" newspaper, gives a very interesting account of the proceedings of "this handsome little hawk," showing it to be a most vicious wretch, and thus sums up its character: "The sparrow-hawk is, in my opinion, the wildest, in some sense the most intractable, the most ungrateful, the most provoking and temper-trying of all birds or beasts that ever were taken under the care of man from the beginning of the world."

"Now," Dr. Coues might say to Mr. Bergh, "if it be true, as Professor Agassiz always maintained, that animals are but embodiments of Divine ideas, we must consider this hawk, with its destructive weapons and murderous instincts, as representing the Divine conception of the sort of discipline to which sparrows should be subjected. It is divinely designed that their numbers should be kept down, so that other birds may have a chance. You thwart the Divine intention by artificially fostering them, and bringing about an unnatural state of things that is injurious. I would leave them to the Creator's universal and fundamental law of natural selection, which is a safer guide than blind, impulsive philanthropy, and I merely included street boys, with hawks, parasites, and a thousand other destructive agencies as the means of preserving the great balance among the orders of life."

The difficulty with Mr. Bergh is, that he puts behind his philanthropy, and as an impelling motive to it, an erroneous view of nature. The doctrine of Divine designs is a dangerous one to handle, because it cuts both ways, and proves too much. If the beneficent indications in nature are to be accounted for on the hypothesis of "intentions," so must the maleficent indications, and how are we to escape from the conclusion that cruelty also is designed? If we should say that the world was constructed and is administered on the principle of the "prevention of cruelty to animals," would it be quite true? Are not the means and appliances of destructive cruelty universal, and, if "intended" at all, were they not intended for their cruel uses? It would require an extensive museum to show us all the exquisite contrivances with which living creatures have been furnished to torment and kill each other. They were not made each with a gland to secrete chloroform that might be used in producing painless death. But, in place of any such kindly contrivance, there are claws, talons, beaks, tusks, fangs, hooks, saws, blades, stings, and malignant poisons in infinite variety of modification and adaptation for crushing, rending, tearing, lacerating, and torturing living and sensitive creatures; and these grim implements are furnished to all the grades of animate beings on the earth, in the sea, and in the air, from microscopic infusoria to colossal beasts that range the forests. Nor is this all: the creatures that are armed with these weapons of destruction are animated by the deadliest instincts to use them; in fact, they are driven to it by the very law of self-preservation. "Kill, that you may live," is the mandate of universal necessity.

But the roots of all this pitiless carnage strike still deeper into the method of nature. Life is wasted through these sanguinary devices with an infinite prodigality. Sensitive organisms to be sacrificed by suffering seem to be the cheapest things in the universe. The amount of inanimate matter is limited; but creatures formed out of it, and capable of pain, are boundlessly unlimited. Space restricts the material, but living organisms are multiplied for

ever in time. Destruction but makes room for more destruction; and not only is the onflowing river of life full to its banks, but ten thousand-fold more creatures are born than can be preserved. Each species reproduces at a rate that is out of all relation to the possible means of subsistence. If Mr. Bergh's sparrows could multiply at their normal rate, unchecked by the agencies of decimation, they would take possession of the world, and humanity and philanthropy would end together. And so it has ever been through the countless ages of the earth's history; so that its very rocks, for miles in depth, are filled with the fossil remains of innumerable tribes of creatures, which warred with each other through geological periods, and have now utterly perished. And it is to-day as it has been through the immeasurable past—millions of species scattered over the earth's surface, from pole to pole, are engaged in a struggle for existence, that is carried on everywhere with unrelenting severity.

From the point of view of sentiment alone, this is not a pleasant picture. Considered by itself, a hawk with a sparrow in its talons is not suggestive of beneficent intentions. If all this remorseless destruction has been beneficently designed, we must widen our notions of beneficent design. Science does this, by showing that out of the universal agony Nature is slowly, very slowly, working up to a better condition of things. In the sanguinary struggle the fittest survive, the ill-adapted and less perfect are slain, and there comes improvement. The value of this progress is to be estimated by its terrible cost. Through the destruction of tribes with what seems an almost infinite wantonness have finally come creatures with higher capacities of enjoyment, as well as correlative suffering, and an order of beings that have acquired great power over the conditions of pleasure and pain. In man, the last term of advancement in the animate series, ameliorations and modifications of his primal savage propensities have gone on, until there has grown up a set of feelings that are kindly, merciful, sympathetic, and benevolent; and they have at length become so strengthened and organized in our nature that they are characterized as "the humane sentiments," or the "spirit of humanity." These are the final product of man's moral evolution, and, although the reminiscences and survivals of savagery in the shape of military systems still linger, yet the kindly, merciful, and generous emotions are steadily gathering force in the hearts of men, and are becoming more and more the predominant law of the social state. Terrestrial life has had a tragic history, but, when under the stern discipline of a mortal competitive strife the primitive cannibals have been so utterly transformed that many of their descendants have come to find their highest pleasure in the gratification of the sympathetic feelings, and even to regard the brute creation with a tender solicitude, as evinced by the organization of societies for the prevention of cruelty to animals, who shall say that the grandeur of the end does not justify all the terrible means by which it has been attained?

LITERARY NOTICES.

THE EVOLUTION OF MAN: A POPULAR EXPOSITION OF THE PRINCIPAL POINTS OF HUMAN ONTOGENY AND PHYLOGENY. From the German of ERNST HAECKEL, Professor in the University of Jena, author of the "History of Creation," etc. In two volumes, with 330 Illustrations. New York: D. Appleton & Co. Pp. 970. Price, $5.

THIS work is now the great text-book of a great subject. Darwin wrote on "The Descent of Man," and Haeckel, with greater learning, writes later upon the same subject. The interest in these volumes will mainly depend, of course, upon the reader's interest in the questions it considers. Those who wish

to know how the problem of the origin of man now stands in the light of science, whether they believe in the doctrine of evolution or not, will turn to this exposition of it by one of the first of living biologists, and thus satisfy their curiosity and post up in a discussion which is beginning to engross a large share of the attention of thoughtful men all over the world. Those who accept the doctrine of evolution and wish to become familiar with its higher applications to organic life, and whose concern with the subject is strictly scientific, will also turn to this work to get the latest and fullest knowledge that has been reached concerning the development of man, and with no other solicitude than to obtain the truth. Yet the book in its subject matter is so greatly in advance of the intelligence and liberality of the age that multitudes will care nothing about it. The mass of people have but precious little curiosity as to where they came from, or how they got here. They generally have some belief about it, which they acquired early, and hold satisfactory, and do not care to have disturbed. To all such, scientific inquiries into these questions are mere impertinence. Then there are others who have a strong antipathy to all these investigations into the germ history of man. As Professor Haeckel remarks: "If we say that each human individual develops from an egg, the only answer even of most so-called educated men will be an incredulous smile; if we show them the series of embryonic forms, developed from this human egg, their doubt will, as a rule, change into disgust." It will obviously be a long time before such prejudices are overcome and there arises a general desire to know the facts concerning the genealogy of man, and his real place in nature. People must apprentice themselves a long time to the study of evolution among the lower forms of life, before they are willing to include themselves in the inquiry. Meantime there are many who are alive to the magnitude and import of the investigation, and these will cordially welcome a treatise from Haeckel on "The Evolution of Man."

Professor Haeckel some years ago published a comprehensive work on "The Natural History of Creation." It was an exposition of evolutionary doctrine through the widest circle of biological phenomena, and was of a much more general character than the present treatise. The development of man is, of course, confined to a consideration of the genesis of the human race. This subject, however, can not be treated alone; and, although it is in a certain sense a sequel to the first work, it is nevertheless much occupied with questions belonging to the general domain of life. The derivation of man is a question of kinship with the whole series of ancestral forms. Haeckel is so much of a pioneer in a great field, hitherto scantily cultivated, that he assumes the right of forming his own terminology, and hence we meet with various unfamiliar words in his pages, although he always makes them clear, and makes them contribute to the clearness of his discussion. The present treatise, devoted to anthropogeny, is divided into two parts: the first, ontogeny, or the history of individual human organisms, concerns itself chiefly with germ history or embryology; and the second, on phylogeny, is a history of the evolution of the various animal forms, from which man has descended in the course of countless ages. Phylogeny is thus a history of evolution, and embraces the sub-sciences of paleontology and genealogy. These terms mark out the divisions and scope of the work, and show that it is occupied with the radical problems of the subject.

Though strictly scientific, this treatise of Haeckel's is in a remarkable degree popular in style and form. It is written with great clearness, and with a view of rendering the subject attractive, and its profusion of elegant wood cuts and colored plates greatly enhances its interest. The time has not come when all biologists will agree with Haeckel as to the genealogical chain that he has made out from man to the moner, and much of his work may be long held as speculative. But Haeckel strenuously maintains that dissent from his array of proofs must be due to their not being sufficiently weighed, or to the bias of rival hypotheses. He writes with the ardor of a man intensely convinced, and with the lucidity and grasp of one thoroughly familiar with the wide elements of his subject. The book may be commended without hesitation to all who wish to acquaint themselves

with what is doing for the advancement of biological evolution.

Moore's Rural Life. An Illustrated Journal for Suburban, Village, and Country Homes. Conducted by D. D. T. Moore. 24 pages; $1.50 per year. 34 Park Row, New York.

The "Rural New-Yorker," an excellent paper, was long managed by Mr. D. D. T. Moore, who now brings his tact, resources, and ripened experience to the establishment of a new enterprise which is admirably initiated, and we have no doubt will meet with the liberal patronage it deserves. Mr. Moore has taken pains to make the first number (for June) of his journal represent the ideal of what the succeeding numbers shall be; and does not send out a hastily prepared sample full of apologies for defects and promises of what he will do when the project gets fairly under way. Moore's "Rural Life" is splendidly illustrated and beautifully printed, and we can give the reader no better idea of the wide and judicious variety of its contents than by enumerating the departments under which its numerous articles are distributed: "Rural and Suburban Homes," "Landscape Gardening," "The Floriculturist," "The Fruit-culturist," "The Arboriculturist," "Entomological," "The Vegetable Garden," "Poultry and Pet Stock," "Editorial Department," "Sketches of Life," "Literary Miscellany," "Natural Science," "Our Book-Table," "Fancy Work and Fashion," "Domestic and Hygienic," "Out-Door Amusements," "Life in the Country," and "Young Folks' Life."

Report on Life-saving Apparatus. Made by Lieutenant D. A. Lyle, Ordnance Department, United States Army. Washington: Government Printing-Office, 1878. Pp. 156, with 54 Plates.

The life-saving apparatus, with which this report is concerned, are mainly guns and projectiles designed for the purpose of carrying a line to an imperiled vessel, or from such vessel to the land. Numerous experiments, made under the direction of Lieutenant Lyle, with different kinds of guns and projectiles, and here recorded in full detail, will doubtless tend to increase the efficiency of our life-saving stations.

A Treatise on Chemistry. By H. E. Roscoe, F. R. S., and C. Schorlemmer, F. R. S. Volume II. Metals. Part I. New York: D. Appleton & Co. Pp. 504. Price, $3.

We spoke of the character of this elaborate and sterling treatise on chemistry, in noticing its first volume, some months ago, and can add nothing now to what we said then in commendation of it, except that the present volume sustains all the promise of the first. We are, however, happy in being able to give the discriminating testimony of one of our highest chemical authorities as to the character of the present volume. Professor Josiah P. Cooke, of Cambridge, having been presented with a copy by the publishers, thus speaks of it: "I received the book several weeks ago, but have waited before acknowledging the gift until I could express an intelligent opinion upon its merits. I find that it fully sustains the reputation of its authors, and has the same merits which were so conspicuous in the first volume. The descriptions of manufacturing processes are remarkably full and clear, and the woodcuts by which they are illustrated admirable. The book will be a great aid in teaching on that account, and I shall be able to refer students to it with satisfaction. Another conspicuous feature of the book is, that it makes prominent many points in the history of chemistry which it is not only a great convenience to have collected, but also very important should not be forgotten by the rising generation of chemists. Lastly, the mechanical execution of the book leaves nothing to be desired and makes it a pleasure to refer to it. I shall await the publication of the second half of the volume with great interest."

The Art of Questioning. By Joshua G. Fitch, M. A. Syracuse: Davis, Bardeen & Co. Pp. 80. Price, 15 cents.

This is the abridged form of a little work published some years ago, by Professor Fitch, when Master of the Borough Road Training School, London, from which he passed to the position of one of her Majesty's Inspectors of Schools. He is an able man, and was a skillful practical teacher. The "Art of Questioning" will be found to contain many hints and suggestions that will be helpful in schoolroom management.

First Steps in Political Economy. By Joseph Alden, D. D., LL. D. New York: Baker, Pratt & Co. Syracuse, N. Y.: Davis, Bardeen & Co. Pp. 153. Price, 25 cents.

In this little volume Dr. Alden has furnished us with an invaluable common-school manual, which can not too soon or too generally be put into the hands of American youth. It is the best introduction to political economy for beginners in primary schools that we have seen, and its universal adoption as a part of the course of elementary study could not fail to result in ultimate widespread benefit. The aim of the author has been "to present simple elementary truths connected with the business activities of life," and this he has done with excellent judgment as respects the subjects chosen and with remarkable clearness and simplicity of statement. There has been a good deal of caviling recently as to whether there is or is not such a science as political economy. No doubt, the excess of modern controversial literature over unsettled questions in political economy has favored this skeptical state of mind; but any one who will look over a little summary of elementary principles like this of Dr. Alden's must be satisfied that there is a broad basis of established truth on which a strict economical science can securely rest.

Notes by a Naturalist on the Challenger: being an Account of Various Observations made during the Voyage of H. M. S. Challenger round the World, in the Years 1872–'76. By H. N. Moseley, F. R. S. With a Map, Two Colored Plates, and numerous Woodcuts. New York: Macmillan & Co. Pp. 620. Price, $7.50.

The opportunity afforded by a four years' sea-saunter in a ship, and with a party dedicated to scientific exploration, was well improved by Mr. Moseley, as is evinced by this goodly volume. Not by any means that the book embodies the scientific results of his extended observations, which when finally worked up will appear in other shapes, but it presents a great deal of interesting scientific and semi-scientific matter in connection with a readable and varied narrative of the experiences of the expedition. It is an especially well-executed book of travels, by an intelligent and thoroughly-trained observer, laboring in circumstances especially favorable for collecting interesting information. The main portion of it was prepared for family reading, written on board the Challenger, and sent home in the form of a journal from the various ports touched at. The materials have been carefully revised, but they take the character of a narrative describing the scenes, the aspects of nature, the curiosities and novelties of animal and vegetable life, and the characters, habits, and social conditions of the different kinds of people encountered along the route. The volume is written in a pleasant, unambitious style, but often with humorous touches and lively descriptions, which increase the attractiveness of its contents. The following passages express some of the impressions of the author, after his return, and are given at the close of his book:

After a voyage all over the world, there is nothing which is so much impressed upon the mind as the smallness of the earth's surface. We are apt to regard certain animals as fixed and stationary, and to contrast strongly with their condition that of forms possessing powers of active locomotion. In reality we are as securely fixed by the force of gravity as is the sea anemone by its base; we can only revolve as it were at the end of our stalk, which we can lengthen or shorten only for a few miles' distance. We live in the depths of the atmosphere as deep-sea animals live in the depths of the sea. We can, like these, crawl up into the shallows, or we can occasionally mount at peril in a balloon; but the utmost extent of our vertical range is a distance no greater than that which we can walk in a couple of hours horizontally on the earth's surface.

The Challenger traveled, on the voyage from Portsmouth and back to the same port, 68,690 miles, and this distance, taking into consideration the time consumed from port to port, was traversed at the average pace of only four miles an hour, or fast walking pace. In an express train on land the entire distance could be conceived of as being accomplished in eight weeks, and, at the rate at which a swallow can fly, in about half that time.

The earth, considered as a comparatively insignificant component particle of the universe, may be justly compared to a small isolated island on its own surface. As, in the course of ages, such an island develops its own peculiar insular fauna and flora, so probably on the surface of the earth alone has the peculiarly complex development of the element nitrogen occurred which has resulted in the various forms of animal and vegetable life.

On the theory of evolution, it is impossible that plants or animals of any advanced complex-

ity, at all resembling those existing on the earth should exist on other planets or in other solar systems. It is conceivable that very low forms of vegetable life may exist on other planets and may have been by some means transported to the earth ; the idea is conceivable, though highly improbable. But it is quite impossible that that infinitely complex series of circumstances which on the earth has conspired to produce from the lowest living forms a crustacean, for example, should have occurred elsewhere ; still less is it possible that a bird or a mammal should exist elsewhere ; still more impossible, again, that there should be elsewhere a monkey or a man.

With regard to any future scientific expeditions, it would, however, be well to bear in mind that the deep sea, its physical features and its fauna, will remain for an indefinite period in the condition in which they now exist and as they have existed for ages past, with little or no change, to be investigated at leisure at any future time. On the surface of the earth, however, animals and plants and races of men are perishing rapidly day by day, and will soon be, like the dodo, things of the past. The history of these things once gone can never be recovered, but must remain for ever a gap in the knowledge of mankind.

The loss will be most deeply felt in the province of anthropology, a science which is of higher importance to us than any other, as treating of the developmental history of our own species. The languages of Polynesia are being rapidly destroyed or mutilated, and the opportunity of obtaining accurate information concerning these and the native habits of culture will soon have passed away.

Problems of Life and Mind. By George Henry Lewes. Third Series, Problem the First. The Study of Psychology, its Object, Scope, and Method. Boston : Houghton, Osgood & Co. Pp. 189. Price, $2.

This work was left unfinished by the author at his death last year, and it has been edited and prepared for the press, as is understood, by Mrs. Lewes, who prefixes to the volume this brief note : "The following problem is published separately, in obedience to an implied wish of the author, and has been printed from his manuscript with no other alterations than such as it is felt certain that he would have sanctioned. Another volume will appear in the autumn."

Like all of Mr. Lewes's philosophical writings, this book is worthy the attention of those interested in the subjects he discusses, for he had an acute and fertile mind, wayward if not independent, and by no means wanting in originality. But he was too versatile for preëminence. A man can not be great in all things, nor really great in anything if he dabbles in everything. Mr. Lewes was novelist, dramatist, linguist, critic, editor, physiologist, historian of philosophy, and psychologist. Much of his work was poor, much middling, and some of it excellent, but he left no impression upon any one subject such as he might have made by concentrating his powers upon it with an exclusive devotion. He was a brilliant talker, and an admirable story-teller ; was sought by society, and was fond of of it, all his striking and varied acquisitions coming readily into play in cultivated social circles. In the latter portions of his life he was more secluded, and gave himself more closely to a restricted line of serious study which resulted in the publication of his maturest work, "The Problems of Life and Mind," of which the present volume is the last issued. He will probably be longest known by his "History of Philosophy," but in the present transition state of biological and psychological theory these latter works will be found well worth consulting. The volume now issued is expository and controversial with regard to varions important psychological questions, but propounds little that is new, the author being content to reargue more fully various positions that he has heretofore assumed. It has undoubtedly been improved in style by passing through the editorial hands of Mrs. Lewes.

Chemical Examinations of Sewer-Air. By Professor William Ripley Nichols. Boston : Rockwell & Churchill print. 1879. Pp. 20.

Dr. Nichols is careful to employ the term "sewer-air" instead of "sewer-gas," inasmuch as the latter phrase gives rise to the erroneous idea that in sewers there exists a distinct gaseous substance possessed of marked distinguishing characteristics ; whereas the fact is, that the gas or air of sewers is a continually varying mixture of the gases which make up the atmosphere, blended with a relatively small proportion of certain other gases formed by the decomposition of the sewage, together with aqueous vapor and vapor of organic compounds. The noxious substances in sewer-air would appear to be either minute solid particles or else particles of vapor, and not gaseous.

Practical Physics, Molecular Physics, and Sound. By Frederick Guthrie, Ph. D., of the Royal School of Mines, London. New York: Henry Holt & Co. Pp. 156. Price, 60 cents.

This is one of a series of hand-books now being published, and which are said to be designed for students and general readers. The grade of these works is intermediate between the so-called Primers and the larger works, professing to give detailed views of the respective subjects. The author in his preface says that his object is, to get beyond mere word-knowledge of the subject. We do not think he has succeeded in this with his book. As a practical and experimental teacher, he may take students through a course in his laboratory and use the book, but the guidance will be given by the instructor and not by the volume. It does not seem to us to be at all a satisfactory guide to that "practical work" which Professor Guthrie says it has been the object of physicists of late years to bring into their teaching. Such books should be skillfully constructed to promote the self-help of pupils, and we see no trace of this quality in the present hand-book. There is a good deal of scientific information in the volume, of course, but much of it runs into mathematical expression which makes it unsuitable for general readers and ordinary students. The illustrations are indifferent, to say the least; the elementary experiments to illustrate sound and waves are postponed to the close of the volume, and no figures are given to illustrate them. A list of the materials required to make such experiments closes the volume. In short, the book seems to have been produced by an inexperienced educator, though its author has evidently a good knowledge of its subject.

Hearing, and how to keep it. By Charles H. Burnett, M. D. Philadelphia: Lindsay & Blakiston. Pp. 152. Price, 50 cents.

The multiplication of health-books is a good sign. If they were not wanted they would not be published, and if they are bought it is to be inferred that they are read. Attention is therefore being drawn to the subject, and, when it is sufficiently thought about and permanent interest in it awakened, great practical good will be certain to result. Dr. Burnett's volume is the first of a series of "American Health Primers," and if the subsequent works are as good as this the series will be valuable. The first part of his little volume is devoted to the structure and physiology of the ear, and it is illustrated by excellent diagrams. The second part is devoted to diseases of the ear, with hints regarding their management, and to the care of the ear in health. It is a judiciously written and very useful little monograph.

The Art of Singing. By Professor Ferdinand Sieber. Translated from the German, with the Addition of an Original Chapter on the Hygiene of the Voice, by Dr. F. Seeger. New York: William A. Pond & Co. Pp. 175.

Professor Ferdinand Sieber's "Catechism of the Art of Singing" is a standard work in Germany, where it has passed through many editions, and Dr. Seeger has done an excellent service to the community in translating it. His familiarity with the structure of the vocal organs and his wide experience in treating them when out of order have drawn his attention to the art of singing as related to health, and induced him not only to render into English Sieber's valuable work, but to prefix to it an interesting and instructive essay on "The Hygiene of the Voice." Those interested in the art of singing, either theoretically or practically, will find this volume well worth consultation.

A Popular Treatise on the Currency Question. Written from a Southern Point of View. By R. W. Hughes, United States Judge of the Eastern District of Virginia. New York: Putnams, 1879. Pp. 222.

The author of this essay argues against "inflation," and warmly approves the national banking system. He condemns the demonetization of silver, and holds that "the public debts of the world can not be paid, nor even their interest met, in gold at an appreciated value. . . . The legal-tender quality," he predicts, "will ere long be restored to silver throughout Europe." But, if that quality is not restored, then "there will be left the alternatives of diluting the currency there with paper money, or the civil convulsions which the Socialists and Communists stand ready to inaugurate."

Report of the Public and High, also of the Normal and Model Schools of Ontario, for the Year 1877. Toronto: Hunter, Rose & Co. print, 1879. Pp. 251.

There is much in this report to which we should like to call attention, but we can find space only for a few passages from the section entitled "Physical Science." "We are pleased," write the Inspectors of High Schools, "to be able to report that the teaching of physical science is making real progress in the high schools. After some experience of the practically inoperative and too expensive programme which was universally in force some years ago, it was decided by the Council of Public Instruction to limit the amount of work prescribed in this department, with the view of having a little done well. It was accordingly determined that only one of the physical sciences should have a place in the programme of lower school-work. On account of its intimate connection with the other physical sciences, and its great practical value, chemistry was selected, and the results have justified the policy adopted. . . . In a considerable number of schools enthusiasm for chemistry is manifested by both the teacher and his pupils. . . . The number of teachers capable of teaching chemistry has largely increased, and the number of pupils who are afforded the opportunity of beginning the study of that branch of knowledge in a proper manner is greater than ever before."

Word and Work: or, Scientific and Mosaic Geogony compared. By P. G. Robert, a Presbyter of the Diocese of Missouri. St. Louis: W. B. Chittenden. 1879. Pp. 29.

The writer of this essay would be a mediator between Science and the Bible, but fails to exhibit his credentials as referee from either side. The world of science surely is not prepared to accept his exposition of the facts of geology; and his exegesis of Scripture passages is altogether too light and airy to meet the approval of Biblical scholars. As for the class of devout believers in the letter of the sacred word, they must be shocked at the author's temerity in explaining away the manifest meaning of the inspired record.

The Wisconsin Tornadoes of May 23, 1878. By W. W. Daniells, Professor in the University of Wisconsin. Pp. 41, with Plates.

The meteoric phenomenon described in this pamphlet was the simultaneous occurrence of three separate tornadoes in a comparatively narrow belt of country in southern Wisconsin. That there *were* three separate tornadoes appears evident from the observations made on the spot by Professor Daniells. The perpendicular velocity of the wind in such tornadoes can be appreciated from certain calculations made by the author of this pamphlet. At a point in the track of one of these three tornadoes a horse, weighing about 1,100 pounds, was carried over twenty rods; in another place a horse, of about the same weight, was carried eighty rods. Now, a horse of this size would not expose a lifting surface to the wind of over fourteen square feet. To lift such an animal, then, would require an upward pressure of the air of $\frac{1100}{14} = 78{\cdot}5$ pounds per square foot. This pressure is produced by wind moving with a velocity of 124·6 miles per hour.

An Etymological Dictionary of the English Language, arranged on an Historical Basis. By Rev. W. W. Skeat, A. M. In Four Parts. Part I. A—Dov. New York: Macmillan & Co., 1879. Pp. 176. Price, $2.50.

A knowledge of the etymology of words is of essential importance in fixing their meaning; hence a work like that named above can not fail to be useful, if only the author brings to his task the requisite scholarship and tact. We have read but a few of the titles in this dictionary; but so excellent did they appear, both in substance and in form, that we have no hesitation in warmly commending the work to our readers.

The Animal, Vegetable, and Mineral Kingdoms. By Mrs. N. B. Walker. New York: Wilbur & Hastings print, 1879. Pp. 18.

The author points out the advantages to be derived from the study of natural history in public and private schools, and makes some sensible observations on the mode of interesting young pupils in such studies.

Bulletin of the United States National Museum, No. 10. Contributions to North American Ichthyology, No. 2. The same, No. 12. Contributions to American Ichthyology, No. 3. Washington: Government Printing-Office, 1878.

The first of the two volumes named above is by Dr. David S. Jordan, and consists of two parts, viz.: 1. Notes on Cottidæ, Etheostomatidæ, Percidæ, Centrarchidæ, Aphododeridæ, Dorysomatidæ, and Cyprinidæ; 2. Synopsis of the Siluridæ of the Fresh Waters of North America. In Number 12 of the "Bulletin" are published two papers, viz.: One on the distribution of the fishes in the Alleghany region of South Carolina, Georgia, and Tennessee, with descriptions of new or little known species—the joint work of Dr. Jordan and A. W. Brayton; and another, entitled "Synopsis of the Family Catastomidæ" ("Suckers"), by Dr. Jordan.

The American Statistical Review. Vol. I., No. 1. Quarterly. New York: D. Appleton & Co. Pp. 120. Price, $5 per year.

The purpose of this publication is, says the editor, Mr. Charles S. Hill, in his "salutatory," "to enable the capitalist, the tradesman, the farmer, and the mechanic to possess a condensed work, regularly issued, giving facts and official figures that affect their immediate interests, for their convenient reference."

PUBLICATIONS RECEIVED.

The Reign of the Stoics: History, Religion, Maxims of Self-Control, Benevolence, Justice, Philosophy. By Frederick May Holland. New York: Charles P. Somerby. 1879. Pp. 248. $1.25.

Problems of Life and Mind. Third Series. By G. H. Lewes. Boston: Houghton, Osgood & Co. $2.

Color-Blindness. By B. Joy Jeffries, M. D. Boston: Houghton, Osgood & Co., 1879. Pp. 329. $2.

Spiritual Communications. By Henry Kiddle. New York: Authors' Publishing Co. 1879. Pp. 350. $1.50.

Man's Moral Nature. By R. M. Bucke, M. D. New York: Putnam's Sons. 1879. Pp. 210. $1.50.

Conversations on Art Methods. By Thomas Couture. New York: Putnam's Sons. 1879. Pp. 262. $1.25.

Sportsman's Gazetteer and General Guide. By Charles Hallock. With Maps. New York: "Forest and Stream" Publishing Co. 1879. Pp. 908. $3.

Pott's Disease. By N. M. Shaffer, M. D. New York: Putnam's Sons. 1879. Pp. 82. $1.

The Great Fur Land; or, Sketches of Life in Hudson's Bay Territory. By H. M. Robinson. With numerous Illustrations. New York: Putnam's Sons. 1879. Pp. 358. $1.75.

Money in its Relations to Trade and Industry. By Francis A. Walker New York: Holt & Co. 1879. Pp. 339. $1.25.

Ueber die erzführenden Tieferuptionen von Zinnwald-Altenberg. Von Ed. Reyer. With 5 colored Plates. Vienna: Alfred Hölder. Pp. 60.

Hall & Benjamin's Illustrated Catalogue of Chemical and Physical Apparatus. New York: Hall & Benjamin, 191 Greenwich Street. Pp. 216.

Report of the State Board of Health of Wisconsin (1878). Madison: Attwood print. 1879. Pp. 183.

Neurological Contributions. By Drs. Hammond and Morton. Vol. I., No. 1. New York: Putnam's Sons. 1879. Pp. 104. $1.

Mémoire sur le Fer natif du Groenland et sur la Dolérite qui le renferme. Par Laurence Smith de Louisville, Kentucky. With Plates. Paris: Gauthier-Villars. 1879. Pp. 54. Rapport sur un Mémoire de M. Laurence Smith relatif, etc. Commissaires: Saint-Claire Deville, Des Cloizeaux, Daubrée. Pp. 6. *Also*, Note sur un remarquable Spécimen de Siliciure de Fer par M. J.-Laurence Smith. Pp. 4. Both from the "Comptes Rendus de l'Académie des Sciences de Paris."

The Privy System of New Orleans. New Orleans: Hanseil print. Pp. 21. 1879.

Industrial News and Inventor's Guide. Vol. I., No. 1. Monthly. New York: American Industrial Exhibit Co. 1879. Pp. 20. $2 per year.

Journal of Physiology. Vol. II., No 1. With Plates. New York: Macmillan. Pp. 90. $5.25 per volume of 500 pages.

Register of the Lehigh University (1878-'79.)

Report of the Hartford Retreat for the Insane (1879.) Hartford: Case, Lockwood & Brainard Co. print.

A Contribution to the Geology of the Lower Amazonas. By O. A. Derby. From "Proceedings of the American Philosophical Society." Pp. 24.

Influence of Light upon the Decomposition of Iodides. Pp. 14. Relations between the Temperature and Volume in the Generation of Ozone. Pp. 11. By A. R. Leeds. From "Journal of the American Chemical Society."

Brief Compend of French Grammar. By J. W. Mears. Syracuse: Davis, Bardeen & Co. 1879. Pp. 37. 50 cents.

Guides for Science-Teaching: About Pebbles; Concerning a few Common Plants: A First Lesson in Natural History; Sponges; Common Hydroids, Corals, and Echinoderms. Boston: Ginn & Heath. 1879.

Emergencies: How to avoid Them and how to meet Them. By B. G. Wilder, M. D. New York: Putnam's Sons. 1879. Pp. 36. 15 cents.

The Story of the Earth as found in the Rocks. Photographed Chart of the Geological Strata. By B. F. Patterson. Pottsville, Pa.

The Berea Sandstone of Ohio. By Professor E. Orton. Pp. 9.

Report of the Geological Society of Philadelphia (1879). Pp. 30.

Aspergillus in the Living Ear. By C. H. Burnett, M. D. From the "American Journal of Otology." Pp. 36.

Polydactyle Horses, Recent and Extinct. By O. C. Marsh. From the "American Journal of Science and Art." Pp. 7.

National Education in Italy, France, Germany, England, and Wales. By C. W. Bennett, D. D Syracuse: Davis, Bardeen & Co. 1879. Pp. 28. 15 cents.

The Microscope in Medicine and Cerebral

Pathology. By J. N. De Hart, M. D. From the "Chicago Medical Journal and Examiner." Pp. 12.

On a Mode of measuring the Velocity of Sound in Wood. By M. C. Ihlseng, Ph. D. From the "American Journal of Science and Arts." Pp. 8.

A New Form of Compass-Clinometer. By I. C. Russell. From "Annals of the New York Academy of Sciences." Pp. 2.

In the Matter of Certain Badly Treated Mollusks. By R. E. C. Stearns. Pp. 10.

POPULAR MISCELLANY.

Well-Water and Typhoid Fever.—In the summer of 1878 some forty persons in Rochester, whose supply of drinking-water was derived from a certain well, were taken sick with typhoid fever and other zymotic diseases. The health officer had the well closed, so that the people had to get water from other sources. Their recovery was rapid from that moment. A request was then addressed to all the physicians in the city to report the names and residences of all persons sick with typhoid fever. About fifty cases having been reported, health inspectors were sent to the various localities, who inquired into their sanitary conditions, the distance of cesspools, sewers, and privy-vaults from the wells; also whether the patients drank well-water either at their homes or at their places of business. Samples of water were taken from the wells, and submitted for analysis to Dr. Lattimore, Professor of Chemistry in the University of Rochester. The result of the inquiries was to show that, of the whole number of cases of typhoid reported, all but two had followed from the use of well-water; the exceptional cases arose from ill-ventilated apartments in close proximity to foul water-closets. It was also ascertained that a very large number of the wells in the city were situated within an average distance of less than thirty feet from cesspools and privy-vaults, while a great many were distant from them not over ten feet! In Professor Lattimore's report occurs one passage which must be quoted *in extenso*, namely, the one in which he remarks on the significance of the presence of common salt in well-water: "I would direct your special attention to the second column" [of his table showing the amount of solid matters in the water], "which shows the number of grains of common salt per gallon of water. No single indication is of so great sanitary importance in judging of the purity or impurity, and consequently of the safety or danger, of any water. How a substance, which is in itself not only harmless, but by most persons considered indispensable as an article of diet, becomes to the sanitarian a signal of danger in well-water, will be easily rendered apparent. No mineral substance is perhaps so universally diffused as common salt. It exists in the air, hence in all rain-water; in all soils, hence in all well- or spring-water, though often in quantities too minute to be weighed upon the chemist's balance, as is the case in the Hemlock Lake water of this city. Salt being remarkably soluble, it is constantly being washed out of the soil into the streams, and ultimately carried down to its great reservoir, the ocean. We may, therefore, expect to find salt present in all ordinary well-water. What might fairly be considered as the average proportion for uncontaminated well-water in Rochester can be only estimated, but it certainly can not be large. Rivers may derive large quantities of salt from the drainage of manufacturing establishments upon their banks, but wells are not usually thus affected. Therefore, whenever, in well-water, it rises above a very few grains per gallon, it becomes certain that it comes from some other source than the soil. What is that source? A moment's reflection will convince any one that nearly all the salt used for domestic purposes escapes by the way of two channels—the water-closet and the house-drain. Therefore, we should expect, what is always found on examination to be true, that whatever sewage may or may not contain, it always contains salt."

Improved Diaphragm for the Phonograph.—Messrs. Preece and Stroh exhibited at a recent meeting of the London Royal Society a new form of diaphragm, which intensifies the loudness and removes some of the imperfections of the present disk of the phonograph. They had sought for a diaphragm which should give all the finest shades of sonorous vibrations, and, after trying many substances, a stretched membrane of thin India-rubber, rendered rigid

by a cone of paper, was found to give the best effects. Messrs. Preece and Stroh also exhibited a machine for tracing curves of the composite character which represent the sounds of speech, especially the vowel-sounds. By this machine they are able to build up curves by putting together their constituent parts, and thus to study the various theories with regard to vowel-sounds which have been put forward. Several instruments were shown by which the vowel-sounds were reproduced with more or less exactitude by vibrating a disk in accordance with the curves formed by the curve-machine. One of them makes a simple and good siren, reliable for measurements, and gives promise of introducing a new musical machine which will give sweet sounds by the mechanical vibration of a disk. Though the knowledge of vowel-sounds is far from complete, Helmholtz's theory has been fully confirmed by the work the authors have done. The sounds can not, however, be, they say, exactly reproduced by mechanical means at present. Some interesting experiments were made on the loudness of sound, tending to show, it was urged, that sufficient importance has not been attached to the quantity of air thrown into vibration. Disks of different diameter, though vibrated with the same amplitude and pitch, increase in loudness very largely with the increasing dimensions of the disk.

A Large Terrestrial Globe.—A New York artificer, Grube, has constructed what purports to be the largest globe of the earth now in existence, showing all the prominent features of its surface. Its diameter is four feet and about one inch, the scale being one to 10,000,000. The range of even the Himalayas would not be visible upon this globe if the same scale were adopted for the elevations as for the map, and accordingly the relief is made upon a scale which exaggerates heights twenty times. The oceans, seas, and rivers are colored blue; the continents are yellow; the glaciers, icebergs and floating cakes of ice, white. Plains and mountain ranges are clearly shown, and every part of the world is exhibited in its true character. Red, black, and white lines cross the globe to indicate the isothermal belts, the variations of the magnetic needle, the date line where ships correct their logs by skipping from Saturday to Monday, and *vice versa*, and other facts of like character. The map has been corrected in the light of the latest discoveries. The northern coast of Siberia has been much altered in the atlases by the Nordenskjöld Expedition, the ships sailing in deep water over places marked as 500 miles inland, and being compelled to go hundreds of miles around promontories, etc., which are occupied on the maps by bodies of water. The globe is made of wood; the relief is formed by wax. Mr. Grube has been two years in perfecting his globe.

Is the "Uniformity System" an American Idea?—Among the many mechanical geniuses who by their inventions have helped to develop the manufacturing industries of the United States, none is entitled to higher rank than Thomas Blanchard, inventor of the tack-making machine, the machine for turning gun-stocks, that for making shoe-lasts, of an improved process for bending timber, and of many other mechanical contrivances. An interesting sketch of Blanchard's life, written by Asa H. Waters, has recently been published for the purpose of vindicating for Blanchard his just place among American worthies, refused to him by certain historians of our national industries. Mr. Waters's pamphlet is a valuable contribution to the literature of invention, but he is certainly in error when he claims for Blanchard the credit of having originated what is known as the "uniformity system" in manufacture—the idea of making any number of perfectly uniform copies of the several parts of a piece of mechanism so that one copy may be interchanged with any other copy of the same part.

The origination of this idea is asserted by the author for Blanchard in the following terms: "This perfect uniformity of Blanchard's work" (with the gun-stock-turning machine) "suggested the idea of having all the parts of the guns made at the armories perfectly uniform, so as to be interchangeable" (p. 9). Again, same page:

"The War Department, impressed with the importance of having the guns so made that after a battle the broken ones could be readjusted, ordered the Springfield Armory

to make all the parts interchangeable. After two years' effort the thing was accomplished. Lettering and numbering were abolished; all the component parts, even of the lock, were got out in large numbers, and thrown together indiscriminately. Thus was inaugurated the 'uniformity system' so called. . . . It is not claimed that the whole credit of the 'uniformity system' should be given to Blanchard. . . . But to Blanchard belongs the credit of being its forerunner and suggester." And in a letter from Mr. Waters to us this system is declared to be "wholly of *American* origin," and he adds that in Europe it is known as "the American system."

Now, that the *practical execution* of the uniformity system was facilitated by Blanchard's invention is readily admitted; but the idea itself, and the execution of it, on a small scale, belong to an earlier period, and to another country. The all-sufficient proof of this is found in the following letter, written from Paris, under the date of August 30, 1785. The writer of this letter, Thomas Jefferson, addressing John Jay, says: "An improvement is made here in the construction of muskets. . . . It consists in making every part of them so exactly alike that what belongs to any one may be used for every other musket in the magazine. The Government . . . . is establishing a large manufactory for the purpose of putting it into execution. As yet the inventor has only completed the lock of the musket on this plan. He will proceed immediately to have the barrel, stock, and other parts, executed in the same way. The workman . . . . presented me the parts of fifty locks taken to pieces and arranged in compartments. I put several together myself, taking pieces at hazard as they came to hand, and they fitted in the most perfect manner." The letter will be found in the "Writings of Thomas Jefferson."

Insanity in Russia.—The ratio of insane persons to the whole population is extraordinarily high in Russia, namely, as 1 to 450. The causes of this have been investigated by Dr. Finkelburg, member of the Public Health Commission, and he has made it the subject of a lecture. Among the working classes he observes that the lack of physical and intellectual education, insufficient food, unhealthy dwellings, and a certain indolence of mind, contribute partly to the evil. But it is chiefly the abuse of alcoholic liquors that fills the lunatic asylums as well as the prisons. In the former drunkards figure to the extent of a fifth; in the prisons they constitute two fifths. With regard to educated people, the causes of their insanity are naturally very different, and they often date from the earliest education. Children do not, in general, get as much rest as they absolutely need. That a child work diligently, keep its place in class, or quickly advance in the school grades, is all that is demanded, and people do not trouble themselves in the least as to whether the young and tender brain, kept in incessant activity, may not suddenly stop in its functions or its growth. Rousseau insisted on a purely negative education till twelve years of age, and in this he was wiser than our schoolmasters. The child that has lived in the open air to this age without contracting bad habits will have greater force of apprehension and will progress more rapidly than another who has been fatigued by premature work. Among adults, Professor Finkelburg distinguishes two great classes—men of work and men of pleasure. Continual activity and the suitable exercise of all the faculties are necessary to the preservation of intellectual and physical health, for it is the idlers that furnish the greatest number of hypochondriacs. But there is the excess of the overworked man, who is liable to mental maladies arising from fatigue of mind, joined with material cares, absence of sleep, emotions and agitations caused by a goal always imagined but never reached. Professor Finkelburg concluded by urging that every man should try as much as possible to vary his occupations, whatever they be, to give his tired mind agreeable recreation, to take walks regularly in the open air, etc., in order to restore the equilibrium of functions of body and mind.

Survival of Superstitious Beliefs.—Here are a few illustrations of the persistence of superstitious beliefs. They are taken from a paper in "All the Year Round," entitled "Some Popular Cures." Many, if not all of these beliefs, doubtless survive even on

this side of the Atlantic. A cure for whooping-cough, in use not only in England but in North Germany, consists in putting into the mouth of the whooping child a newly-caught fish, and then letting it go again. The cough is communicated to the fish. Another cure for the same malady consists in passing the child nine times under and over a donkey. To charm away warts, an elder-shoot is to be rubbed over them; then as many notches are cut on the twig as there are warts. The twig is buried, and as it rots away the warts disappear. There are persons still living who have been stroked by a hanged man's hand for the sake of dispelling tumors. In Devonshire there is a superstition that, if a person suffering from any disease throw a handkerchief in the coffin of a suicide, the disease will be cured as the handkerchief rots away. In other localities, the fore-foot of a hare, worn constantly in the pocket, is considered a potent charm against rheumatism. A like practice is found in this country, a horse-chestnut taking the place of the hare's foot. In some places the anti-rheumatic talisman is a potato. Bread baked on "Good Friday" is supposed to possess wonderful curative virtues. Such bread, it seems, never grows moldy. It is often kept for years, sometimes as many as twenty. It is most effectual when taken grated in brandy. Nor is it only for man's ailments that Good Friday bread is medicine; it is also considered good for some of the complaints of animals—for instance, it cures "the scours" in calves.

Climate at Great Altitudes.—The "Little Annie gold mine," in Rio Grande County, Colorado, is doubtless the highest gold mine worked anywhere on the globe, its elevation being 11,300 feet above sea-level. An interesting account of the climatic conditions here existing is given by Professor C. E. Robins, in the "Kansas City Review of Science." The geographical position of the camp is 37° 28′ 18″ north, and longitude 106° 30′ west—that is to say, it is in the latitude of Syracuse, the most southerly city of Europe; but, owing to the elevation, the climate is arctic. The mean annual temperature in 1877-'78 was 26·95° Fahr., the maximum being 69° (July), and the minimum −24° (November). The mean maximum was 50·4°, and the mean minimum 4·58° for the twelve months. Snow fell every month except July, 1877; few nights are without frost; the fall of snow is about twenty-four feet per year. The dry atmosphere is scarcely ever *chilly*. Even when the temperature is as low as −10°, the air is generally still. From the middle of November to the middle of June locomotion is performed on snow-shoes—runners of the Norwegian pattern. Absolutely cloudless days are very common. On the 11th, 12th, and 13th of August, the sun, moon, and several stars were visible from 10 A. M. to 2 P. M. Of a lunar rainbow, seen on the evening of August 4th, the same year, Professor Robins says that "it appeared about 9 P. M., the moon being full; and it lasted fifteen minutes. The chromatic scale was complete in the primary, and the secondary arc was perfectly defined around the entire semicircle. The upper outlines of the mountains were but faintly discovered through the blackness of the storm, while the valley of the North Alamosa was flooded under the arch by an inundation of intense light, brighter than that under the most brilliant aurora, but golden." Of parhelia there are about half a dozen striking exhibitions every year. Meteors are frequent, but the author has not observed either *paraselenæ*, aurora borealis, or mirage.

The Seeds of Disease.—It is believed by Pasteur that he has discovered the germs which produce puerperal fever and malignant pustule. The primary organism which engenders puerperal fever he describes as presenting itself in the form of cells united to each other in series of two, four, or six, and each having an average diameter of two thousandths of a millimetre. Of the researches which have resulted in the demonstration of the germs of malignant pustule we take the following account from the "Medical and Surgical Reporter": "M. Pasteur's researches on malignant pustule have proved to him that the disease was produced by the presence of the bacteridium discovered in 1860 by M. Davaine, and this demonstration was made by the application of the method of culture which

M. Pasteur employed in 1857, and which enables him to obtain microscopic organisms in a state of purity—the only means of arriving at certain results. An infinitely small drop of the blood from a case of malignant pustule is taken, and it is sown in the cultivating fluid constituted by a froth of beer-yeast; a little drop of this fluid is taken again, and sown in a new medium of the same kind, and so on. Thus the media of culture may be multiplied indefinitely to a certain extent during years by the aid of a single droplet of blood taken originally from the case, and one may have always a liquid the inoculation of which in certain animals, such as the sheep or Guinea-pig, reproduces in those animals malignant pustulæ. If this fluid is filtered through a plaster filter, nothing results from the inoculation of the fluid parts which have traversed the filter, but, if the figurate elements which remain on the filter be inoculated, all conditions of the pustular disease are produced. It is the same with the cholera of fowls, and perhaps with puerperal septicæmia."

Marey on Electrical Fishes.—Of a communication from Professor Marey to the Paris Academy of Sciences on electrical fishes, a brief summary is given in the "Revue Scientifique," from which we learn that the author employed a telephone in studying the nature of the electrical discharge of the gymnotus, and the torpedo. Physiologists long ago pointed out certain analogies of innervation, chemical composition, and structure observable between muscles and the electrical apparatus of these animals. It remained to be discovered whether these analogies also exist in the functionment of the two organs. Marey's experiments go to show that the electrical and the muscular functions are in reality homologous, and that they are destined to explain each other. The author also investigated the question whether in those species of fishes which give the electrical discharge there is to be observed a multiplicity of electrical discharges just as a multiplicity of shocks are to be observed in muscular action. The experiments yielded affirmative results. They were made according to the graphic method, as also with the aid of the telephone, the latter instrument being specially adapted for this kind of investigation, inasmuch as it gives a sound when it is traversed by successive currents of sufficient frequency.

Variable Stars.—In directing attention to a certain remarkable star, the "Academy" relates an interesting passage of history connected with it. A Jesuit Professor at Ingolstadt, Christopher Scheiner, was one of the first observers of sun-spots, having noticed them in March, 1611. In accordance with the rule of his order, he communicated his discovery to Budæus, his superior, who, being a disciple of Aristotle, would not accept the observation as correct, inasmuch as no such thing was to be found mentioned in the works of "the Philosopher." When Scheiner had satisfied himself that he had made a true observation, he was permitted to publish the fact, but anonymously. Accordingly, he addressed several letters to Welser, a wealthy Augsburg patrician, and a great patron of learned men; these were printed, and copies sent to Galilei and other astronomers. In the autumn of 1612 Welser published three more letters by Scheiner, under the title "De Maculis solaribus," etc., the second of which, dated April 14, 1612, records observations of Jupiter and his satellites from March 29th to April 8th, among them some observations to which Professor Winnecke, of Strasburg, has lately drawn attention. In order to understand why observations of the satellites of Jupiter were mixed up with those of sun-spots, one must bear in mind that at that time Scheiner still assumed the spots to be merely satellites of the sun, and thus avoided inconvenient questions respecting the purity of the sun's light, which the Aristotelians would not give up. While observing Jupiter's satellites he saw something which offered, as he fancied, a new analogy in support of his opinion; for on March 30, 1612, he remarked in the field of the telescope, besides the four satellites, a fifth star, which he had not noted the previous night. This star decreased in brightness from night to night, and had, on April 9th, already passed the limit of visibility. Scheiner, moreover, thought he had remarked a small amount of motion, and he

accordingly considered the star to be a fifth satellite of Jupiter. The statements contained in his letter agree sufficiently with the assumption that the star was or is a variable fixed star, and the diagrams and descriptions indicate that the conjunction of Jupiter and of the star occurred on April 7th. By means of the geocentric place of Jupiter computed for the date, Winnecke has been enabled to identify the observed star with Lalande's 18,886, a star of the eighth or the seventh to eighth magnitude, which, during the last half century, seems to have varied little in brightness. Variable stars, in the sense of the term as now used, were unknown in Scheiner's time, and his description of the rapid decrease of the star's light carries with it some proof of its truthfulness. The spectroscopic observation of this star, with sufficiently powerful instruments, would be very desirable. Its place for 1855, date of the Bonner Durchmusterung, is right ascension 9h. 29m. 21·2s., and declination +15° 52·1'.

Identity of Heat and Light.—In a recent lecture, Mr. W. H. Preece, the English electrician, made the following interesting remarks on heat and light: "These two," he said, "are identical in character, though different in degree; and whenever solid matter has imparted to it motion of a very high intensity—in other words, when solid matter is raised to a very high temperature—it becomes luminous. The amount of light is dependent on the height of this temperature; and it is a very remarkable fact that all solid bodies become self-luminous at the same temperature. This was determined by Daniell to be 980°, by Wedgwood 947°, by Draper 977°; so that we may approximately assume the temperature at which bodies begin to show a dull light to be 1,000°. The intensity of light, however, increases in a greater ratio than the temperature. For instance, platinum at 2,600° emits 40 times more light than at 1,900°. Bodies when raised to incandescence pass through all stages of the spectrum; as the temperature increases, so does the refrangibility of the rays of light. Thus, where a body is at a temperature of 250°, it may be called warm; at 500°, hot. At 1,000°, we have the red rays; at 1,200°, the orange rays; at 1,300°, the yellow rays; at 1,500°, the blue rays; at 1,700°, the indigo rays; and at 2,000°, the violet rays. So that any body raised to a temperature above 2,000° will emit all the rays of the sun. Inversely, the spectroscope may thus be enabled to tell us the temperature of the different lights, and it is perhaps because some lights do not exceed 1,300° that we have all the rays beyond the yellow."

A Horse with a Load in his Stomach.—Dr. Albin Kohn recites in "Die Natur" the particulars of the sudden death of a horse, caused by the presence of a stony concretion in the animal's stomach. The horse was to all appearance perfectly sound and well one morning when carrying his master about his estate, when suddenly he fell dead. A veterinarian opened the carcass to ascertain the cause, and found in the abdominal cavity a stone of about eight pounds' weight, and in the wall of the stomach a hole of corresponding size. The stone was submitted to Dr. Peters, of Posen, for analysis, who first cut it into halves. Each half of the rather round stone—called by Dr. Peters "magenstein," i. e., stomach-stone—looked very much like a Chester cheese. The diameter of the cut surface was from 15 to 17½ centimetres, and concentric rings are visible in it. At the center its texture is radiate. Dr. Peters supposes the animal at some time swallowed a fragment of millstone, and that around this nucleus numerous layers were afterward deposited. Externally the stone is smooth, rather hard, and of a grayish-yellow color; its composition is: ammonio-magnesic phosphate 87½ per cent., organic matter 6¼, water 1⅓, silicic acid 1⅛; other salts ⅜ per cent.

"Jumping Frenchmen."—It is a very instructive narrative which Dr. G. M. Beard publishes of the doings of the "Jumpers" of the woods of Maine and Canada. These jumpers are mostly half-breed French-Canadian lumberers who have acquired the permanent habit, which they can not control, of jumping or striking out with their hands, when commanded to do so by any one who chances to be near. The habit appears to have been acquired, in the first instance, by tickling one another in the winter camps

where they cut lumber. The men are extremely ignorant, and one of their pastimes is this practice of tickling one another. When the jumpers are excited to strike or jump, or to perform any of their automatic acts, they present the appearance of entranced persons: their faces pale, eyes fixed and glassy, and limbs trembling. One of these jumpers is a waiter, and when told suddenly to "drop it," he at once lets fall whatever he may have in his hand. Another has so susceptible a stomach that he at once throws up his meal when any one "gags" or makes the motion of vomiting in his presence. The man has grown thin, and at one time was almost starved. One man, standing on the bank of a pond with a five-dollar goldpiece in his hand, was told to "throw it," and threw the money into the water. Another was standing near a kettle of fish; being told to "jump," he leaped into the kettle. In these acts the jumpers are absolute automatons, utterly without volition or responsibility: they are to be compared to persons afflicted with St. Vitus's dance, hysteria, or epilepsy. Performances of a somewhat similar character were, last winter, witnessed in a town of Vermont during a revival of religion. Here the victims of abnormal religious excitement would roll on the floor in most absurd and undignified attitudes, whence the appellation of "the holy rollers!"

New Process for the Protection of Iron Surfaces.—A new process for protecting iron from rust has been invented by M. Dodé. It consists in coating, either by means of a bath or a brush, any objects in cast or wrought iron (freed from the damp they may contain) with a composition of borate of lead, oxide of copper, and spirits of turpentine. This application soon dries on the surface of the iron, and the objects are then passed through a furnace, which is heated from 500° to 700° Fahr., according to the thickness of the articles under treatment, so as to bring them to a cherry-red heat when passing through the center of the furnace. At this point the fusion of the metallic pigment takes place; it enters the pores of the iron, and becomes homogeneously adherent thereto, covering the objects with a dark coating, which is not liable to change under the action of the air, gases, alkaline or other vapors, nor to scale off from the surfaces to which it has been applied. When any considerable depth of "inoxidation" is desired, the object may be immersed in the composition for the time requisite to absorb a sufficient quantity of it. This process supersedes painting and varnishing, and iron objects thus heated are impervious to rust. The cost of application is about half a cent per superficial square foot.

The Mance Heliograph.—The Mance heliograph, an instrument for signaling by means of reflected solar rays, is now in use among the British forces in South Africa. The signals made by the Mance heliograph are visible, under favorable conditions of position and atmosphere, to very great distances, and have been read as far as eighty and a hundred miles. It consists of a specially prepared mirror, with mechanism for reflecting the sun's rays with absolute precision to any required spot, notwithstanding the sun's apparent motion. By pressure on a finger-key the flashes are made of short or long duration, thus adapting the instrument to the Morse code of telegraphy. A second mirror is provided to permit of signaling being carried on irrespective of the sun's position. The instrument intended for field service weighs from six to eight pounds, and is mounted on a light tripod stand. The working parts are protected from injury during transit, and the complete apparatus admits of being easily carried, as it is also efficiently worked, by one man.

Experiments in Opium-Smoking.—The Russian traveler, Dr. Miclucho Maclay, while recently on a visit to Hong-Kong, experimented on the effects upon himself of smoking opium. The experiment was made at the Chinese Club, and was under the direction of Dr. Clouth, who made the following notes: Mr. Maclay was in normal health, and had fasted eighteen hours before commencing the experiment. He had never smoked tobacco. Twenty-seven pipes, equivalent to 107 grains of the opium used by the Chinese, were smoked in two and three quarter hours at tolerably regular

intervals. The third removed the feeling of languor caused by his long fast, and his pulse rose from 72 to 80. The fourth and fifth caused slight heaviness and desire for sleep, but there was no hesitation in giving correct replies to questions, though he could not guide himself about the room. After the seventh pipe the pulse fell to 70. The twelfth pipe was followed by singing in the ears, and after the thirteenth he laughed heartily, though without any cause that he can remember. Questions asked at this time were answered only after a pause, and not always correctly. He had for some time ceased to be conscious of his actions. After the twenty-fifth pipe, questions asked in a loud tone were not answered. After the last pipe had been smoked, he remarked, "I do not hear well." Forty minutes later there was a slight return of conciousness, and he said: "I am quite bewildered. May I smoke some more? Is the man with the pipe gone already?" Fifteen minutes later he was able to go home, and then retired to bed. He woke the next morning at 3 A. M. and took a hearty meal, after his fast of thirty-three hours. During the next day he felt as if he had bees in a great hollow in his head, as well as a slight headache. The organs of locomotion were first affected, next came sight and hearing, but Mr. Maclay is positive that there were no dreams, hallucinations, or visions of any sort whatever.

Descartes on the Invention of the Telescope.—Concerning the invention of the telescope, Descartes, in 1637, wrote as follows: "This invention, as illustrious as it is useful, is, to the shame of our science, due to chance and mere experiment. About thirty years ago there lived in Alkmaer, in Holland, a certain Jacob Metius, who had never studied, though both his father and his brother were professors of mathematics. He found his greatest pleasure in making burning-glasses and mirrors; and when he was thus once in possession of a lot of glasses of different forms he happened to look at the same time through two glasses, of which the one was a little thicker in the middle than on the edge, and the other thinner in the middle. He afterward fixed them in a tube, and in that way originated a telescope, from which all the later ones have been made, for as far as I know nobody as yet has sufficiently explained what form these glasses by right ought to have. On the 17th of October, 1608, this Jacob Metius (otherwise Adriaanz) applied to the States-General of the Netherlands for a reward as the inventor of the instrument two years previously. But one of his own countrymen had anticipated him in this application, for Jan Lapprey (otherwise Hans Lippersheim) had some days before presented to the States a similar instrument. Thus, then, the first *authentic publication* on record of this great invention was made when Lapprey delivered his telescope to the States-General."

"This Jan Lapprey," says the author of a paper in "The Observatory," "was born in Wesel, and followed the trade of a spectacle-maker in Middelburg. On October 2, 1608, he solicited the States for a patent for thirty years, or an annual pension for life, for the instrument he had invented, promising them to construct such instruments only for the Government. After inviting the inventor to improve the instrument, and alter it so that they could look through it with both eyes at the same time, the States determined, on October 4th, that from every province one deputy should be chosen to try the apparatus and make terms with him concerning the price. The committee declared, on October 6th, that it found the invention useful for the country, and nine hundred florins were offered to Lapprey for the instrument. He had at first asked three thousand florins for three instruments of rock-crystal. He was then ordered to deliver the instruments within a certain time and the patent was promised him on condition that he kept the invention a secret. Lapprey delivered the instrument in due time. He had arranged it for both eyes, and it was found satisfactory."

A Carnivorous Goose.—In communicating to "Nature" an account of a goose which had learned to eat flesh, the Duke of Argyll remarks upon the circumstance as being extremely curious, but at the same time notes the fact that cows are largely fed on fish-offal in Scandinavia. This carnivorous goose is in the possession of Mr.

W. Pike, of the island of Achill, Ireland, and was hatched in 1877 by a tame eagle. The eagle having laid three eggs, Mr. Pike took them away, substituting for them two goose-eggs, upon which the eagle sat, and in due time hatched two goslings. One of these died, and was torn up by the eagle to feed the survivor, who, to the great surprise of its foster-parent, refused to touch it or any other flesh-meat offered by the eagle. In course of time, however, the goose learned to eat flesh, and now the eagle always calls it by a sharp bark whenever there is any fresh meat in the cage. On hearing the call the goose hastens to the cage, and greedily swallows all the flesh and offal which the eagle gives it.

The King-Vulture.—A traveler in Colombia, André, confirms from personal observation the popular belief in that country that the urubu (or black vulture) dreads the king-vulture (*Sarcoramphus papa*), and slinks away when that monarch of the Cordilleras makes his appearance. On one occasion André saw the carcass of a cow covered with urubus which were greedily devouring it. Suddenly a black point appeared in the sky overhead. One of the urubus uttered a cry, and at once all the heads were raised to observe the enemy, who was coming ever nearer and nearer. In less than a minute the urubus had fled to a respectful distance, and the king, descending like a thunderbolt into the entrails of the carcass, began his meal with avidity. This operation took up half an hour, the urubus in the mean time standing around in a wide circle. They did not return to the carcass till after the king had risen majestically into the upper air.

The Size of Lightning-Rods.—In calculating the relative sectional areas of copper and iron lightning-rods, certain important factors are commonly overlooked, and thus of necessity incorrect results are obtained. The relation usually given, that an iron rod should have four times the sectional area of the copper rod, is based on the fact that copper conducts electricity six times as well as iron, while the melting-point of iron is about fifty per cent. higher than that of copper, and 6 divided by 1·5 is equal to 4. This simple treatment, as is pointed out by R. S. Brough, in the "Philosophical Magazine," is incomplete, because it neglects these factors: 1. The influence of the rise of temperature in increasing the electrical resistance of the metal; 2. The difference between the specific heats of the copper and iron; 3. The fact that the iron rod being made several times more massive than the copper one, it will require a proportionally greater quantity of heat to increase its temperature. Taking these considerations into account, Mr. Brough finds that the sectional area of an iron rod should be to the sectional area of a copper rod in the ratio of 8 to 3.

NOTES.

The forty-ninth meeting of the British Association for the Advancement of Science will be held at Sheffield on Wednesday, August 20, 1879, under the presidency of Professor G. J. Allman, M. D., LL. D., F. R. S., L. & E. M. R. G. A., Pres. L. S. General Secretaries, Douglas Galton, P. S. Salator; Assistant Secretary, J. E. H. Gordon.

The American Association for the Advancement of Science will assemble this year at Saratoga Springs, New York, on August 27th. Excursions to various points are contemplated, and the meeting promises to be a successful one. Officers of the Saratoga meeting: President, George F. Barker; Vice-President, Section A, S. P. Langley; Vice-President, Section B, J. W. Powell; chairman of Chemistry Sub-Section, Ira Remsen; chairman of Microscopy Sub-Section, Edward W. Morley.

The French Association for the Advancement of Science will meet this year at Montpellier, on August 28th. The officers of the Association are: President, M. Bardoux; Vice-President, M. Krantz; General Secretary, Count de Saporta.

We have received, but too late for mention in our June number, a circular announcing the second session of the Chesapeake Zoölogical Laboratory of Johns Hopkins University. The Laboratory is announced to be opened about June 20th, at Crisfield, on the Eastern Shore of Chesapeake Bay. One of the barges of the Maryland Fish Commission will be fitted up as a laboratory, and another barge will be used as a dormitory. As there will be room for only

ten persons, none but those who are already acquainted with the methods of zoölogical work will be accepted as members of the party. A fee of ten dollars will be charged for the use of the laboratory outfit. Board will cost about five dollars per week.

Mr. J. D. Putnam, Secretary of the Davenport Academy of Sciences, has presented to the editor of the "American Naturalist" photographs of two pipes found in a mound situated in Muscatine County, Iowa, one of them representing an animal like a bear, the other *an elephant*. Were the mound-builders, then, contemporary with the mammoth on this continent? In Grant County, Wisconsin, there was lately discovered an elephant-mound—that is, a mound fashioned to represent an elephant.

Heinrich Wilhelm Dove, Professor of Physics in the University of Berlin, and distinguished for his researches in meteorology, died at Berlin, April 5th. He was born in 1803 at Liegnitz, Silesia; studied at the Universities of Breslau and Berlin, and in 1826 took the degree of Doctor at the latter university. In the same year he became Assistant Professor of Physics at Königsberg, and a few years later at Berlin, becoming full professor in 1845. He was the author of several important works on meteorology, climatology, electricity, and polarized light. A few years ago he was appointed director-general of all the observatories of Prussia. His work on "The Law of Storms" was translated into French and English.

Professor J. Lawrence Smith, of Louisville, Kentucky, was elected by the Paris Academy of Sciences, on March 31st, a Corresponding Member in the room of the late Sir Charles Lyell.

The National Academy, at its meeting in April, adopted a resolution declaring that "provision should be made by State legislation for giving instruction in the principles of the metric system in all the elementary schools of the country, and for making a knowledge of the system a requisite for admission into educational institutions of higher grade; also that laws ahould be enacted by Congress, enforcing the use in the domestic mail service of a metric unit of postal weight identical with that already employed in the foreign, requiring the assessment of duties upon merchandise imported under metric invoices to be made in accordance with a tariff adapted to metric denominations of weight and measure, and expressing the weights of all coins issued from the mints of the United States in grammes and milligrammes, and no longer in grains and fractions of grains, as at present."

A French traveler, Charnay, who has explored the east and west portions of the island of Java, claims to have discovered a close affinity between the remains of the civilization introduced by Hindoo Buddhists and that of ancient Mexico.

In the best schools in Holland there is always, besides the teacher, an attendant who sees to the personal condition of each child upon daily entering the school. The object of this supervision is to promote among the children a due regard to cleanliness and tidiness, and also, as far as possible, to prevent the introduction of contagious diseases.

Mr. Francis Galton advocates the use of experiments in teaching physical geography. Erosion of the earth's surface by streams, the formation of sand, gravel, and clay deposits, the formation of deltas at the mouths of rivers, and other phenomena of physical geography, or physiography, he would illustrate with the aid of a can of water and a quantity of sand, gravel, and clay. Most of the great features of physical geography, as glacial action, mountain formation, etc., might be effectually taught by like simple experiments.

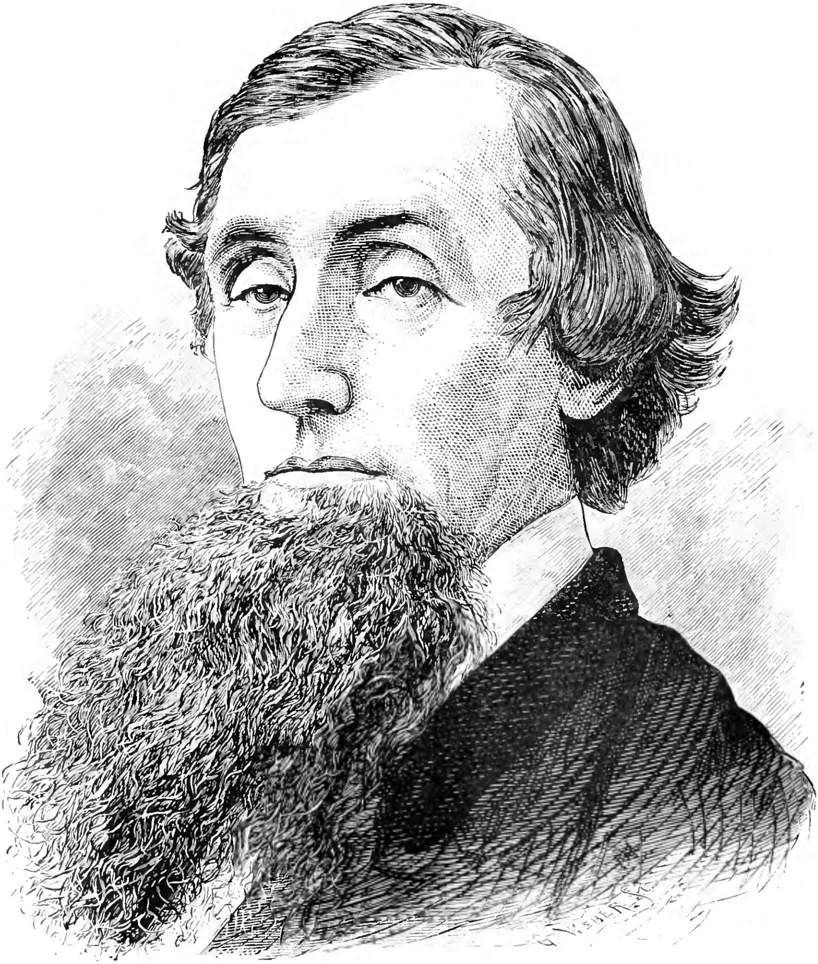
It has been found, by Messrs. Exner and Goldschmidt, that the electrical resistance of pure water uniformly decreases as the temperature rises; at 99° centigrade it is about one-third of what it is at 20°. A similar result is observed with water acidulated with sulphuric acid.

Professor Asaph Hall, discoverer of the satellites of Mars, was, on May 18th, chosen a Corresponding Member of the Academy of Sciences of Paris, receiving thirty-three votes in a total of forty-seven. Among his competitors were Schiapparelli, Respighi, and Warren de La Rue.

Four volumes of the literary and scientific remains of the late Professor W. K. Clifford are announced for early publication, viz., a volume of mathematical papers; two volumes of essays and lectures; and a small volume containing three popular lectures on "Seeing and Thinking."

In a report made by the Department of Agriculture of the Italian Government, it is stated that borax used instead of salt in preserving butter imparts to the butter no flavor whatever, while it is entirely innocuous. Samples of fresh butter, in which much of the buttermilk was purposely left, have retained their natural fine flavor without change for three months after having been salted with borax.

M. Paul de Soleillet recently set out from St. Louis, on the Senegal, with the intention of reaching Algeria through the Sahara.



DANIEL VAUGHAN.

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REMOVAL OF INHERITED TENDENCIES TO DISEASE.

By J. R. BLACK, M. D.

A LIMITED collection of statistics and the observation of physicians concur in showing that about two thirds of our people inherit a tendency to some disease, or to a defective vitality in some organ of the body. In very many instances the overshadowing heritage is toward an untimely death, while in others it is simply toward some chronic insufficiency which embitters many a year of life.

The number who think themselves doomed to a premature death by some innate blood defect is very great. At this moment hundreds of thousands are ready to interpret every sign of thoracic derangement as the harbinger to the development of that dreaded inheritance —pulmonary consumption. Taking into consideration that, according to the last census, about seventy thousand throughout our land are swept into the grave each year by this disease, cause for alarm seems sufficiently ample. The aggregate of foreboding, of suffering, and of heart-wringing grief at untimely separations through this scourge alone, would be terrible to contemplate were we capable of apprehending it as a whole. Add to this the heritage in numerous instances of a tendency to rheumatism, to gout, to epilepsy, to insanity, to cancer, and the host of those distressed in mind or in body attains a painful magnitude. A subordinate and large group of heritages are yet to be added. Every year thousands are brought into the world with digestive organs so imperfect that the slightest indiscretion precipitates misery; others are tormented for life by the development of an inherited tendency to *migraine*, to neuralgia, or to asthma; and not a few through the same agency lose their sight or their hearing during the prime of life.

To go on with a bare enumeration of the organic defects handed down from parent to child would occupy many pages. Enough has been said to convey some idea of the magnitude of the evil. There is no cause of grief, of misery and suffering that will bear comparison with it. Even that of war is a mercy compared with the torments of disease. The seventy thousand annually slain by one disease, consumption, involves an amount of suffering which no battle-field can equal. In the latter death is usually sudden, and therefore almost painless, while death by consumption implies months of torture by the destruction of lung tissue inch by inch.

In an age distinguished for progress and philanthropy, that such a gigantic evil has received scarcely any attention is worthy of remark. In large part is this doubtless due to the prevailing opinion that the development of inherited tendencies to disease is unavoidable—a visitation upon children for the sins of the fathers, not to be averted. Even among medical men is there a prevailing skepticism as to the renovation of defective blood. Yet it will be admitted by the candid among them that this doubt is not grounded on a careful study of the subject, but on some desultory observations, and on some remarks to be met with here and there in medical literature. In palliation this may be said, that as a rule physicians are far more intent in discovering the best means of curing than of averting disease, well knowing that the latter is a thankless and little honored pursuit, while the former brings large returns of gratitude and reward.

If in our forty millions of people some twenty-six million inherit some constitutional defect, the question is of deep and wide interest whether such imperfection can be erased, and, if so, by what means. The interests involved are : a nearer extension of life to its normal limits, greater freedom from disease and deformity ; a diminution in the necessity for ever-growing asylums for the helplessly imperfect and diseased ; an increase of the ratio of able-bodied men for the defense of the state in time of need ; a lessened necessity for the consumption of drugs and the support of forty thousand physicians ; and an increase and perpetuation of the blood which has been our chief glory as a nation.

The nearer the approach to physical perfection, the less likely will be the occurrence of derangement and disease from slight causes, such as atmospheric vicissitudes, and the greater the chances that the termination of life will be natural, or from the harmonious, progressive, and painless decay of the body as a whole. Death by disease through one organ is abnormal, violent, and torturing ; there should be no weak points in the citadel of life. Men with excellent physical organizations do not need to be ever on the watch for the preservation of their health. They possess that buoyancy of life which carries them safely over all the minor influences inimical to healthy action. All that is required of them for the preservation of such a vital excellence is, that

unfavorable influences shall not be too intense, or suffered to act upon them for any great length of time. On the other hand, those defectively organized can not overstep the bounds of the most watchful prudence without incurring suffering. Only by the most minute and accurate knowledge of hygiene, and unswerving attention to its requirements, are they enabled to avoid pain, disease, and an untimely end.

The genius of our civilization in its physiological aspect is to make spendthrifts of us all of our vital riches. It includes no such aim as race improvement. True, some youthful culture of the head and heart is supposed to reach after that object. But it does not. It looks only to immediate success in social distinctions, or to winning in competitive struggles, not to the more remote objects of our improvement as a race. Indeed, the instances in which physical degeneration, by the prevailing injudicious and highly prized head-culture, is not thereby begun, are altogether exceptional. Compare the highly educated son with his father, and a perceptible diminution in the grade of constitutional stamina is nearly always manifest. Continue the process for a generation or two, and a progressive deterioration will ensue until there are only sickly boys to grow up into invalided manhood.

Very few ever think of, and yet fewer ever seek after, the accumulation of vital riches. Only when brought to suffering by poverty of this kind is the mind aroused to any interest in the subject. Prior to the inception of disease, a thoughtless squandering of vital reserve is what our social practices systematically encourage ; and when as a consequence corporeal structure is inharmoniously developed, when debility, disease, and untimely death ensue, these are not regarded as the evidences of a fatal flaw in the existing system of civilization, but as matters of prevision which alone concern Providence and the doctors. The constitutional vigor, thus so blindly spent, renders frequent demands upon the highest resources of the healing art urgently necessary. And it must be confessed that in prolonging the life of defective blood there are displayed a skill and care never before equaled. During the more primitive phases of civilization, those of weak and defective blood were more liable to be swept into an untimely grave than they are to-day. Now, all such are skillfully nursed up to the fertile period, to the multiplication and perpetuation of their kind. The profound study, the active sympathy, and systematic charity bestowed upon the wrecks of our race for their cure and preservation, when compared with the prevailing indifference as to the means of preventing the steady increase of such helpless unfortunates, is far from flattering to our foresight in economy and beneficent work. Vast infirmaries, hospitals, and asylums dot the land to shelter and cure the ever-increasing ratio who become pitifully and hopelessly bankrupt in vital condition ; yet there is no money, no labor, light, or system brought to bear to hinder this downward career, but very much of all —thoughtlessly we will allow—to aid in its increase and perpetuation.

Optimists assure us that even if insanity, idiocy, deaf-mutism, blindness, and intractable disease and deformity be upon the increase, the evil is not unmingled with good, as it at once serves the twofold purpose of illustrating and exercising the benevolence of the age.

The only rational interpretation that can be put upon the manifestations of defective blood is, that they are the prodroma of its extinction. If the genetic conditions are continuously applied, such will be, as familiar experience often illustrates, the ultimate result; the salient points of the process being, a large infant mortality, death before reproduction, and infertility. On the theory of Dr. N. Allen, that increase of population is mainly governed by the law of approximation to perfection in bodily structure and harmony of function, the postulate can be easily proved that, as a people, we are gradually but surely degenerating. Dr. Toner, the compiler of vital statistics at the national capital, has found that "there is undoubted evidence of a gradual decline in the proportion of children under fifteen to the number of women between fifteen and fifty years of age throughout our country."

The vital statistics of Rhode Island have been carefully and intelligently collected for many years by Dr. Snow, who states that there has been a gradual decline in the birth-rate among those of American parentage for the last twenty years. The same is true of Massachusetts, and, in fact, of New England; the birth-rate being actually lower than in any country of Europe, France alone excepted.

The causes of race degeneration are usually very complex; some pertaining to environment, others to a faulty personal hygiene. Through heredity all the evil effects are accumulated and perpetuated. But fortunately there is a principle in life which tends to antagonize and obliterate the destructive tendency of these innate defects upon life. If nothing of the kind existed—if there were no opposing force—the failure of physiological action would be rapid, uniform, and progressive, until morbid energy gained its fatal mastery over that which tends to hold organic structure in a cycle of harmonious changes.

What is known as reversion, and termed by Darwin "the great principle of inheritance," furnishes the clearest conception of this opposing energy. Of its essential cause nothing is known, but as to its steady operation there is indubitable evidence. In two well-defined conditions of organic life, its steady influence may be observed: in processes that are normal, and in those that are abnormal. The influence of reversion in the perpetuity of normal characters is fully recognized, but the same can not be said of its true relation to those that are abnormal. Writers who have treated upon this point apparently consider the principle as one which tends to restore a lost character without regard to its nature, or, in other terms, that a quality ill suited for the continuance of life, and which has disappeared for one or more generations, is quite as likely to reappear as one well suited. This

conclusion appears to be sustained by ordinary observation, although the conditions which bring about the reappearance of abnormities may be quite different from those which tend to restore lost normalities. The more attentively, however, the subject is considered, the more apparent does it become that the differences in the two cases are far greater than has been supposed, extending back to the antecedents, to the nature, duration, and outcome of the process.

One of the constants of reproduction is more or less variability in the offspring, and this may be healthy or physiological, or it may be morbid. When of the former, it is in no way incompatible with life, and may prove permanent to the blood; but more commonly it is supplanted by older characters, which may have disappeared for one or more generations. The nature of the prepotent tendency to reversion seems to be grounded upon a single antecedent, that of prolonged transmission. As a rule, it happens that the longer this has occurred the more deeply fixed does any character become, and hence the more likely, when caused to vanish by modifying conditions, to reappear through reproduction.

Exceptionally, it is true, modifying circumstances seem to have so ripened in the organism for a variation that a change of structure and function is uninterruptedly transmitted.

That the prolonged existence of characteristics should tend to fix them strongly upon the blood is in entire harmony with familiar experience. For example, there is nothing permanent in the minute diversities among the individuals of a race, but the general type has long existed, and is preserved for generation after generation with unbroken fidelity. No competent observers think it possible to raise the intellectual grasp of a stupid family or race to the highest average by the culture of one or two generations. Time and continuity of influence are indispensable to the fixing and maintenance of intellectual excellence. To the influence of these elementary conditions is no doubt due the wide disparity between the transmission of instinctive and intellectual skill. In the latter process the thoughts and actions are so numerous and diversified, that the continuance of any one is necessarily short and evanescent, while in the former they are few and always in the same narrow channel. In this way the instinctive brain-impressions of the animal are grooved or deeply stamped into its structure, making their acts a necessary resultant; while those of intelligence leave but a shallow impress, so that skillful execution can only be attained by individual training and practice.

When the variation that springs from the ripe influence of modifying conditions is of a normal character, it has no inherent quality which renders indefinite perpetuation impossible. Let its favoring conditions be continuously applied, and it may become permanent to the blood, and thus acquire the prepotency of reversion. Quite otherwise is the result with variations of an abnormal or morbid character.

Their presence implies an unceasing and more or less violent struggle between the tendency to an untimely death and the natural term of life. The prolonged existence of such variations, especially when they affect the more important organs, is scarcely possible ; progressing in acute attacks, or through descent, either toward reversion or toward lineage extinction. Indeed, if abnormities were in their nature as permanent and compatible with the life of the blood as normalities, they would cease to be such, and all distinctions between them would vanish. Some deviations, however, from ordinary development, such as polydactylism, can not be considered morbid, and are in no way incompatible with the continuance of life.

Organic variability is mainly, if not entirely, an effect of changes in condition. The increased use or disuse of any part, a change from one climate to another, and of the quantity or quality of food, have long been noticed to be specially influential. The various species of domesticated plants and animals are far more variable than the same when wild, a difference readily accounted for by the fact that the latter are far less migrant ; their nutriment and the culture of parts undergo little if any change in great lapses of time. Some variations, like that of the loss of wool which our sheep undergo when placed within the tropics, are apparently grounded upon adaptation to relation, others upon adaptation to use, and others are dependent on methodical selection.

One and all of these diverging tendencies are opposed by a single conservative principle, that of reversion. The tendency of animals long domesticated when they become feral to revert to the pristine type might also be supposed to arise from adaptation to relation. But the tendency is often seen when there has been no apparent change in the conditions, as in the many and familiar instances of atavism ; and more decisively, by the crossing of species. The experiment of the Earl of Powis is one example of the many which evince the marked tendency to reversion through the crossing of blood. He had some domesticated hump-backed cattle crossed by the wild species from India, with the result, not of producing a medium grade of characteristics, but of a marked reversion to the ancient.* Here, adaptation to relation can not be regarded as effective ; only through the indelibility of types by prolonged transmission is such a prepotency explicable.

The principle of reversion is the touchstone of the fitness for survival of blood variations normal in character. If they withstand for indefinite generations the tendency to be supplanted by older and more deeply fixed characters, their fitness is proved, and at the same time they acquire prepotency for strong maintenance against fresh deviations. The principle is therefore eminently conservative, and not a mere blind tendency of the organic processes. Unlike the coarse and obtrusive struggle for existence between independent organisms, it is

* "Animals and Plants under Domestication," vol. ii., p. 19.

a molecular contest of refined organic principles, not visible or audible in its details, but in general scope and outcome as manifest and beneficent in its operation as its more familiar congener.

Though the conservative influence of reversion is quite apparent in variations of a normal kind, it is far more so in those that are morbid or abnormal. Here the struggle between the variation and the tendency to the maintenance of durable types is usually so sudden, violent, and quickly decisive, that it is vividly realized. Upon the tendency of deranged actions to revert into the old channels of health does the therapeutist ground all hopes of his ability to assist in the process. When that is manifestly impotent, no means he can bring to bear will arrest the speedy termination of life. Cullen attributed the tendency in disease to reversion or recovery—for they are identical—to a *vis medicatrix naturæ*. The conception is little more than a barren ideality, and does not accord with the fundamental truth that of causes we can know nothing—only of the relations of phenomena to each other. The *vis medicatrix naturæ* has not been shown to have any antecedent; it is simply a name for a supposed entity, apparently latent until disease appears. According to the views here adduced, it is resolvable into the general principle manifest in all kinds of organic life: the strong tendency to the maintenance of characters which a great lapse of time has proved are the most fit. If this generalization be truly grounded, it adds another to some more notable in which modes of action once considered as produced by independent forces were really transmutations of one.

The frequency with which the principle of reversion gains the mastery in attacks of acute disease is one of the most striking phases of vital action. Form and function are seen to revert to their old types and channels of action as if they had never nearly perished. The struggle against abnormal variations is violent, continuous, but not prolonged. Either the abnormity or reversion quickly gains the mastery; in the former case the end is dissolution, in the latter health. In some instances the morbid variation is slow, insidious, or mild in nature; the struggle is then less conspicuous, more prolonged, but never suspended. When the abnormal variation gains the mastery, it does not survive or establish its fitness by indefinite perpetuation, and so acquire the prepotency of reversion. Untimely death is the signal and sequel of its mastery, and until this or reversion gains supremacy no peace or continued harmony of action is possible. True, blood affected by a morbid variation chronic in its nature often displays sluggish and varying fortunes in its struggle with reversion for mastery; favoring conditions now giving reversion the ascendancy, then unfavorable conditions impart a renewed energy to the unhealthy tendency. Yet a marked lineage struggle for survival is rarely very extended—the compass of a single life's observation not unfrequently witnessing its close.

Morbid variations of structure and function present three leading phases of action, the acute, chronic, and diathetic. The primary causes of each are the same, a faulty personal hygiene and an unfavorable environment, but a derivative cause very generally predominates in the heritage of a defect or taint in the blood. In acute variations the struggle between the tendency to death and the tendency to reversion is usually short and severe, but decisive. The contending forces are often so nearly equal that a very little will turn the scale one way or the other. Chronic variations only differ from acute in this, that they are milder, or are more tolerable to the vital autonomy. The same inherent principle struggles in each for the restoration of health, although the process is not so impressively realized in the chronic as in the acute form, by a rapid and well-defined course. What dissimilarity there is in the two series of actions is wholly one of time and degree, not of nature, the struggle between the tendency to health and the tendency to disease presenting almost every conceivable phase of activity, and lasting from a day to months or even years.

As no one can say precisely when acute diseases end and chronic begin, the distinction being arbitrary and accepted for convenience, no more can any one say exactly when a slow disease is changed into a diathesis. In fact, there are no sound reasons in support of the opinion that such a change ever sharply occurs; but there are in support of this, that a slow disorder is often gradually toned down until it merges into a diathesis, when it is then known as a predisposition. During the gradual disappearance of a slow disease one of untutored and gross perceptions may decide recovery to be complete, while the acute adept may be able to discern the manifestations of the disorder subsequently for months. Indeed, there is scarcely any room for doubt that, if our senses were far more acute, a diathesis or tendency to some special disease would be disclosed in definite signs of imperfection, or of disorder. A diathesis is often seen gradually merging into development, and development into a diathesis, and the frequency with which this is seen to recur in the same person gives tone to the conclusion that the latter state is only a very mild or occult phase of the former. Any ordinary observer, with a predisposition to some disorder, is aware that very slight exciting causes usually serve sufficiently to increase the imperceptible imperfection as to bring it within the cognizance of the senses. But there is yet more indubitable evidence that a series of morbid changes may be going on in the body of which no cognizance can be taken. During the incubative stages of scarlet fever, measles, small-pox, and syphilis, the contagium of each has a definite period of maturative action before the signs of disease are in any way apparent. When a wave of cold air sweeps over a continent it develops in one a pneumonia, in another a rheumatism, in another a fever or an attack of neuralgia, upon the great majority no bad effects whatever. Can it be doubted that some definite imperfection which

constitutes the diathesis must have preëxisted to each of the diseases named, even though it was in no manner obvious to the most careful observer?

Acute, chronic, diathetic, or incubative disease may therefore be regarded as merely expressing the various gradations of morbid processes, from the very rapid to the very slow, from the very severe to the very mild, and from the most readily perceived to the imperceptible.

As acute diseases are only compatible with life for short periods, they are rarely transmitted; in fact, they are excluded from the list of diseases properly inheritable. The open chronic forms of disease, such as scrofula and syphilis, are not unfrequently handed down to the offspring, but far oftener is the heritage of the diathetic grade. This is better tolerated, or more compatible with the continuance of the life in the blood than the open chronic forms which quite commonly render the procreative act abortive.

Before bringing our subject to its practical bearings, it seems necessary that the reader should divest his mind of any vestiges of the glamour of superstition which has so long been around the reproductive process. Darwin succeeds in this with admirable directness by putting reproduction simply as a process of growth. Two cells with somewhat diverse qualities commingle and by gradual accretion develop individual peculiarities. The new self-multiplying stream of blood sometimes appears as if derived in unequal proportions from the two progenitors. This may, however, be supposed to arise from another cause, a temporary or permanent prepotency of the gemmules of one parent over those of the other, which gives them greater activity and power of fission. Be this as it may, every new blood-stream is but a continuation of two older, wonderfully compressed at the junction. The preëxistent forms and forces are only slightly modified by mixture, and by the influence of some variable conditions. In all the general outlines of qualities it is the same blood, exhibiting the same tendencies near or remote to good or to evil, to health or to disease. If there has been a slow struggle—often so subtile as to be at times occult in the parental organism between the tendency to the maintenance of a permanent type and some morbid predisposition—the same is almost certain to be carried on in the blood of the child. The leading causes of any divergence from the continuation of the struggle consist in the crossing of blood, and in the application of modifying conditions when impressibility is at its acme, as from germinal coalescence to adolescence.

With the foregoing facts and deductions in mind, and ranging them around what Dr. Farr terms the great hygienic problem—how to free the people from hereditary disease—the solution does not appear as hopeless and difficult as has been supposed. On the side of release is the great conservative principle of reversion; on the side of continued

subjection are the existing taints or defects of blood, and the continued application of their genetic causes. The third factor is what in political phrase "holds the balance of power." The tendency to the maintenance of durable types is *in limine* more potent than abnormal variations, else recovery would be the exception instead of the rule. But, if the genetic influences of a defect or of an abnormity be kept in continual action after its inception, the ultimate triumph of reversion is a very rare outcome. Great care in acute diseases is commonly taken that the third factor shall not turn the scale against the tendency to reversion, far less is expert systematic supervision as to this brought to bear in chronic disease, while in the diathetic there is as a rule worse than a fitful, or no care—the misjudged application of causes best calculated to increase and intensify the defect or taint in the blood. In illustration of the statement in reference to acute disease, take a case of pneumonia, the result of a protracted out-door exposure to a sudden fall of temperature, with an abundance of atmospheric humidity. Suppose these genetic conditions continued throughout the attack, the likelihood of reversion gaining the mastery would be reduced to a very small ratio. Yet this is the very course generally adopted by those who have a diathetic defect in their blood, actually oftentimes under the belief that it is the best mode of hindering the full development of a dreaded inheritance. Take for example that of pulmonary consumption. Its leading genetic causes are, an in-door sedentary life, unwholesome food for the stomach, and above all depraved and unwholesome air-food for the lungs. Yet the father and mother with this taint in their and their children's veins, realizing that their boys and girls are delicate, from the moment of birth upward seclude them far more than ordinary in close, ill-ventilated rooms, they coddle and pamper them with unwholesome delicacies, and in effect carefully attend to the very conditions which secure weak and foul air as nutriment for their lungs and blood. Thus it is that the precise causes which originate the defect are with more than ordinary assiduity kept in constant action, and the tendency to reversion utterly overwhelmed.

Every candid person will acknowledge that this is no fancy picture, but a true outline of the practices in nearly every household which has such a shadow over it, so that, if the complete supremacy of reversion over a diathesis is not often seen when compared with the frequency with which it gains the mastery over acute disorders, the difference in results is what might be anticipated, as the unfavorable influence of a third factor is brought to bear on the former and not on the latter. The power of reversion in acute disease is readily discerned, the necessity of observing favoring conditions well known; they are under expert supervision and not difficult to carry into effect. Precisely the opposite is true concerning a diathesis. In chronic disease the struggle between reversion and morbid tendency is often so mild and slow as to be almost imperceptible; in the diathesis it is as a rule entirely so,

only made obvious now and then before development by some mild aggravating cause, such as, when toward dyspepsia, by slight sensations of discomfort after hearty meals; when toward tuberculosis, by frequent signs of catarrh after ordinary weather-changes.

Not so much by plain evidences to the senses as by mental analysis can the reality of a struggle between a diathesis and reversion to the normal type be apprehended. Yet it is only the *vis medicatrix naturæ* of medical writers carried from the very obvious in acute disease to the less perceptible in chronic, and to the imperceptible in the diathetic. Although the opinion is very generally entertained that those who inherit a diathesis should be careful as to their mode of life, what effect there is on practice is commonly more injurious than beneficial. This arises from the lack of expert supervision, and the sway of some popular traditions as shallow as they are unsound. More frequently does their observance act as aids instead of hindrances to the development of an inherited dyscrasia. Then the observance of the true conditions which favor reversion in an inherited diathesis require no little judgment, self-denial, patience, and intelligence. In acute disease the physician and nurse see that the conditions of reversion are duly observed. Reputation, love, and alarm are all brought to bear for their enforcement. In a diathesis none of these are evoked until the development of all its signs renders the fact apparent that the fatal work has reached its culminating stage. The diathetic subject while in good health is himself indifferent and incredulous as to his danger. For the young to be always as careful of their health as an invalid, in other words, not to live and do as the careless multitude, presupposes unusual self-denial and discretion. Obstacles like these not only thwart the principle of reversion, but contrariwise strengthen and evolve abnormal variations.

Advantage being carefully taken of reversion in acute disease, less so in chronic, and scarcely at all in diathetic, that the eradication of unfortunate inheritances should have received so little credence is the natural outcome of the prevailing ignorance or neglect of the conditions. It is well, however, to bear in mind that this prevailing belief is simply and wholly the result of antecedents as they are and have been, not as they might and should be.

The instances in which the operation of the law of reversion has had anything like an unimpeded sway are far more commonly casual than designed. Circumstances render a change of environment and habits of life necessary or desirable, and these may happen to include its favoring conditions, or they may not. Those who recover from the tendency to an abnormal inheritance through intelligent design ought to be found, if anywhere, in the ranks of the medical profession, and especially among those of them who have given the science of health no little attention. A work assigned me by the American Medical Association brought some statements under my eye which confirm this

inference in the most unmistakable manner. I select a few examples in reference to the tuberculous diathesis, at once the most prevalent, the most liable to be transmitted, and, according to the prevailing opinion, the least amenable to preventive measures.

A quite old and widely known physician makes this statement: "My father and mother were cousins. Father had hæmoptysis at twenty-eight, and was supposed dying of consumption, but recovered, and died in his sixty-seventh year of cancer of the stomach. He had cicatrices in his lungs. Mother died of phthisis late in life, having given birth to six children. These are all alive. No consumption in any of them, nor in twenty-seven grandchildren and fourteen great-grandchildren."

Another highly reputable physician writes: "On maternal side evident tendency to tuberculosis. My only brother—I had no sister—died of phthisis, aged twenty-six. I had hæmoptysis, with cough, repeatedly, between the ages of twenty-two and thirty-five. Wife healthy, and gave birth to five children—ages between thirty and forty-eight. None of them, nor eight grandchildren, have exhibited any signs of pulmonary consumption."

Another writes: "Consumption on father's side, having lost one if not two sisters by the disease. Mother died of it in her forty-third year. Six children were born to them—all alive and healthy, the youngest past his fiftieth year. They are all free from any signs of tuberculosis, as are also thirty-one grandchildren and eleven great-grandchildren."

Yet another writes: "Father died of paralysis, mother of consumption; also one of her brothers. Grandmother also died of what is presumed to have been the same disease. Of seven children, varying from forty to sixty, none have shown any pulmonary disease."

These statements are made by physicians well known for their interest in sanitary science. Through their knowledge and influence, they and their kin have been able to take a wise advantage of the power of reversion. As there are hundreds of thousands throughout the land who have this fearful taint in their blood, a knowledge of the true conditions for its renovation becomes of great importance. It is not within the scope of this paper to enter upon details, but this much may be said, that intelligent and unwavering hygienic observances all through life, but especially from birth to adolescence, constitute the cardinal requisites. Not the hygiene, however, taught in almanacs, in gossipy newspapers, or by itinerant sensational lecturers, but by the most accomplished scientists. A thorough mastery of its principles and details, so as to secure a correct application of them at the various periods, emergencies, and contingencies of life, is absolutely necessary. In short, those with an unfortunate inheritance—like those suffering from an attack of disease—need the knowledge of an expert to enable them to take a wise and full advantage of the principle of re-

version. If this be attained, and applied vigilantly and continuously, there is, I have no doubt, far more probability of recovery from an unfortunate inheritance than from an attack of ordinary disease. The chief peril in the latter condition lies in the severity of the struggle, the ground of safety in the former in its mild prolongation, whereby the law of reversion can have unimpeded opportunity through the long and steadfast application of favoring conditions to restore the body to its pristine vigor. The thought may occur that not many have the requisites alleged to be needful for the restoration of defective blood. Yet even this has an outcome not to be deplored. High intelligence, and a will subordinate to it, will survive; while feeble minds and groveling instincts will carry the blood on to overt disease, to untimely death, and to extinction.

THE STORY OF THE NOVEMBER METEORS.*

By G. JOHNSTONE STONEY, F. R. S.

WHEN observers band together to watch every quarter of the sky, and to keep on the lookout through the whole night, the number of meteors that present themselves is very great. In this way it has been ascertained that upward of thirty on the average, which are conspicuous enough to be seen without instruments, come within the view of the observers stationed at one locality. And it is computed that telescopic meteors must be about forty or fifty times as numerous as those visible to the naked eye.

These results may be obtained from observations made at one station; but when concerted observations are carried on at different stations several other facts of interest come to light. By simultaneous observations at distant stations, it has been discovered that the height of meteors above the surface of the earth usually ranges from one hundred and twenty down to twenty miles, the average height being about sixty miles; that the direction of their flight is toward the earth, either in a vertical or in a sloping direction; and that their speed in most cases lies between thirty and fifty miles a second.

We thus arrive at the conclusion that *visible* meteors are phenomena of our own atmosphere; and as the atmosphere reaches a height, at most, of one hundred and fifty miles, and is, therefore, but a thin film over so vast a globe as the earth, it is obvious that the spectators at any one place can see only a very small portion of the meteors which dart about through all parts of this envelope. After making allowance for this, we are forced to conclude that no fewer than 300,000,000

* Lecture before the Royal Institution, February 14, 1879.

of these bodies pass daily into the earth's atmosphere, of which about seven millions and a half are large enough to be seen with the naked eye on a clear night, and in the absence of the moon.

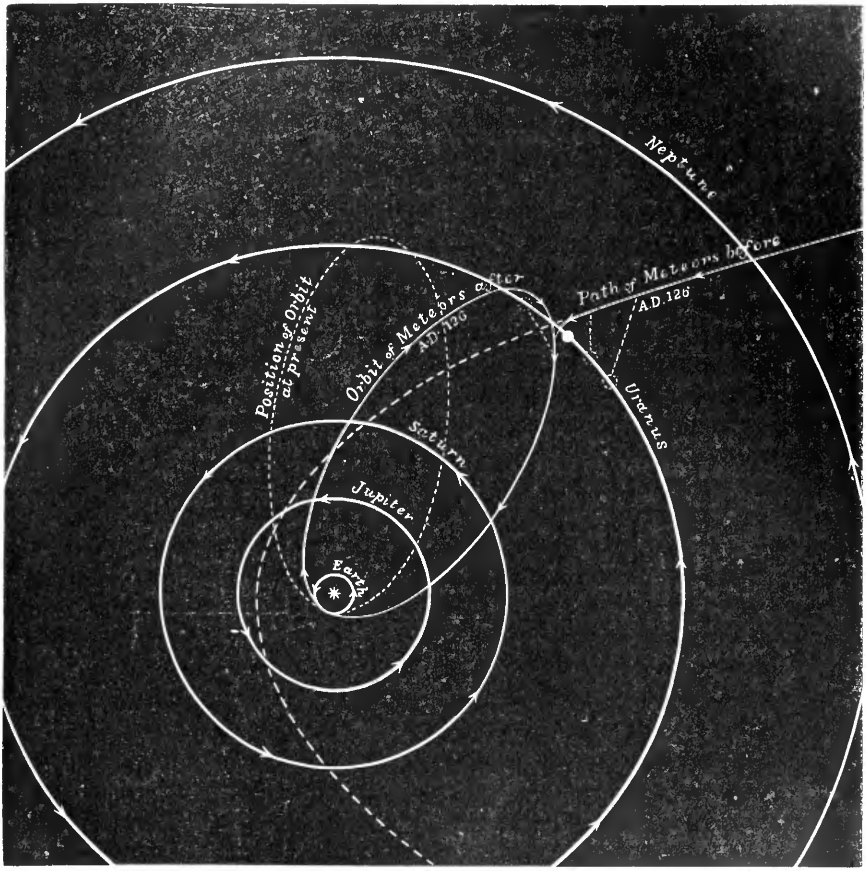
From the direction and swiftness of their flight, it is manifest that meteors are visitors from without. They plunge into our atmosphere, and the resistance to which they become then suddenly exposed must raise them to a temperature which exceeds that of the most intense furnace. The heat is enough first to melt and then to dissipate in vapor the most refractory substances, and it only now and then happens that even a part of a meteor escapes this fate, and reaches the ground. They are for the most part lost in vapor ere they get within several miles of us. The difficulty, indeed, is not to account for their incandescence, but to see why they do not emit a greater flood of light where the heat must be so intense. And, in fact, they can not be other than very small bodies, or they would be much brighter. The average weight of those visible to the unassisted eye appears to be under an ounce, and the telescopic ones, of course, are much lighter.

Meteors may be distributed into two very obvious classes—casual meteors, which dart irregularly through the sky, and meteoric showers, which stream into our atmosphere in one definite direction, and at stated intervals of time. We are concerned at present with the meteoric showers. Many such are known to exist, of which the principal are the August shower, through which the earth passes every year upon the 9th, 10th, and 11th of August, and the great November shower, which is discharged upon the earth three times in a century. The November meteors are those about which most is known, and it was of these, therefore, that the lecture chiefly treated.

To make their history intelligible, it is necessary to explore, in some degree, the regions from which they come. For this purpose your attention is called to this great diagram, every hundredth of an inch upon which represents a distance in nature equal to the interval between the earth and the moon.* The distance from the earth to the sun on this diagram is a decimetre, that is, four inches; and, on the same scale, the nearest fixed star would have to be placed at a distance of twenty kilometres, or upward of twelve miles.

In these vast celestial spaces, there are no rails over the roughnesses of which the train must be made to rattle, if it is to move at all; there are no wheels to be worn out; there is no air in which a wind must be produced, or through which noise will be propagated. The music of the spheres is not a sound audible to the ear, and an impediment to motion: it is harmless, it is altogether good, it is the pleasure of the human mind when it understands the great works of nature. There is no thundering along through the heavens. All is silence and peace round the planets as they swiftly glide. Bodies which sweep

* The scale of the diagram exhibited was rather more than forty times the scale of the accompanying woodcut.



in this way without obstruction through the depths of space, are ready to yield at once the due amount of obedience to the attraction of the sun. Accordingly, each meteor which traverses the elliptic orbit represented in the diagram, mends its pace so long as it is gliding along that half of its course in which it is approaching the sun, because here the sun is drawing it forward as well as sideways; and the forward attraction increases its velocity, while the sideward attraction bends its path into the oval form. The meteor takes upward of sixteen years to traverse this part of its orbit, and all this time its velocity is on the increase. It has attained its greatest speed when it reaches the point of its orbit which is closest to the sun, near to which is the place where it crosses the earth's path. As it passes this point its velocity is twenty-seven miles a second. The earth moves at the rate of nineteen miles a second in very nearly the opposite direction, so that if the meteor happen to strike the earth, the velocity of its approach is the sum of these two numbers, or forty-six miles a second; and it is at this enormous speed that it plunges into our atmosphere.

But if it escapes the earth, and continue its course along its orbit, it loses speed for the next sixteen years, until it passes the farthest part of its orbit at its slowest pace, which is about a mile and a third per second. In each revolution its velocity oscillates between these extremes. Its orbit is so vast that it takes thirty-three years and a quarter to get round it.

Such is a good picture of the course pursued by each member of the great November swarm. There are countless myriads of meteors in this mighty group, each one moving independently of the rest, each one fulfilling its own destiny. They form, together, an enormous stream of meteors, the dense part of which appears to be about 100,000 miles in width, and of immense length. The orbit along which they travel was represented on the diagram by an ellipse of 207 centimetres, or close upon seven feet, long—i. e., by an oval about as long and broad as the hall-door of a house; and the length, breadth, position, and motion of the swarm in 1865, before it reached the earth, would be represented on the same scale by a thread of the finest sewing-silk, about a foot and a half or two feet long, creeping inward along the orbit, the rear of the column having been between the orbits of Jupiter and Saturn, and the front of it nearly as far in as the earth's orbit. The actual train which is thus represented was so amazingly long that even moving at the rate of twenty-seven miles a second, it took upward of two years to pass the point where its path crosses the earth's orbit. The earth passes this point on the morning of the 14th of November in every year. The head of the dense part of the stream seems to have reached the same point early in the year 1866. The earth was then in a distant part of its orbit, but on the following 14th of November we came round to the place where the great stream of meteors was pouring across our path. The earth then passed through the swarm, just as you might imagine a speck, too small to be seen by the eye, to be carried on the point of a fine needle in a sloping direction through the thread which represents the meteors. The earth took about five hours to pass through the stream; and it was Europe, Asia, and Africa, which happened at the time to be moving forward. Accordingly, it was upon this side of the earth, on that occasion, that the meteors were poured, and they produced the gorgeous display in our atmosphere which many here must remember. In 1867, when we came round again to the same place, the stream of meteors was still there. America, this time, chanced to be the part of the globe which was turned in the right position to receive the shower. In 1868 the mighty swarm had not passed, and in subsequent years, when we came round to the proper place, we still found ourselves among outlying stragglers of the great procession.

In 1799 Humboldt was traveling in South America, and on the morning of the 12th of November in that year the November shower was poured out over the New World. Humboldt's description of this

shower seems first to have fixed the attention of scientific men upon the subject. But he contributed still more to the advance of our knowledge by the success with which he insisted that nearly all such phenomena are periodic, and that therefore there is reason to hope that the causes of them are discoverable. Shortly after, the periodic character of the August meteors was established; and when the next return of the November meteors to the earth took place, when there was a magnificent display of them exhibited to Europe in 1832, and a still more impressive spectacle seen in America in the following year, the attention of scientific men was thoroughly aroused.

In England meteors began to be systematically observed, and in this way all that knowledge about them has been acquired which was referred to in the beginning of the lecture. In France the records of antiquity and the annals of distant nations were ransacked; and by this most useful antiquarian search, no less than ten visits of the November swarm, previous to the shower observed by Humboldt in 1799, have been brought to light. But the first great step toward gaining a knowledge of their orbit was made by Professor H. Newton, of New Haven, in America, who published in 1864 two memoirs, in which he discussed all the accounts that had been collected, extending back to the year A. D. 902. He found, by comparing the dates of the old observations with the modern ones, that the phenomenon is one which recurs three times in a century, or, more exactly, that the middle of the swarm crosses the earth's path at intervals of thirty-three and a quarter years. He further showed that meteors which thus visit the earth three times in a century must be moving in one or other of five orbits which he described; and that therefore, if means could be found for deciding between these five orbits, the problem would be solved. The five possible orbits are—the great oval orbit which we now know the meteors actually do traverse every thirty-three and a quarter years; a nearly circulat orbit, very little larger than the earth's orbit, which they would move round in a few days more than a year; another similar orbit in which their periodic time would be a few days short of a year; and two other small oval orbits lying within the earth's orbit. But we owe even more to Professor Newton. He also pointed out how it was *possible* to ascertain which of these orbits is the true one, although the test he indicated was one so difficult of application that there was at the time little hope that any astronomer would attempt it. Fortunately, our own Professor Adams, of Cambridge, was found able to grapple with the difficulties of the problem, and willing to encounter its immense labor, and to him we owe the completion of this great discovery.

A comparison of the dates of the successive showers which have been recorded shows that the point where the path of the meteors crosses the earth's orbit is not fixed, but that every time the meteors come round they strike the earth's orbit at a point which is twenty-

nine minutes (i. e., nearly half a degree) farther on in the direction in which the earth is traveling. In other words, the meteors do not describe exactly the same orbit over and over again: their path in one revolution is not exactly the same as their path in the next revolution, although very close to it. Thus, their path in A. D. 126 was that which is represented by the strong oval line in the diagram, but, in the seventeen centuries which had since elapsed, it has gradually shifted round into the position represented by the dotted ellipse. This kind of motion is well known to astronomers, and its cause is well known. It would not happen if the sun were the only body attracting the meteors, but arises because the planets also draw them in other directions; and although the attraction of the planets is very weak compared with the immense power of the sun, still they are able to drag the meteors a little out of their course round the sun, and in this way occasion that shifting round of the orbit of which we are speaking. Now, in the case of meteors which are really traveling in the large orbit, this shifting of the orbit must be due to the attraction of the planets Jupiter, Saturn, Uranus, and the Earth, while, if they had traveled in any of the four smaller orbits, the planets that would be near enough and large enough to act sensibly upon them would be the Earth, Venus, and Jupiter. Accordingly, if any one could be found able to calculate how much effect would be produced in each of the five cases, the calculated amount of shifting of the orbit could be compared with the observed amount, which is 29′ in thirty-three and a quarter years, and this would at once tell which of the five possible orbits is the true one.

These papers of Professor Newton's were published in 1864. Before the computations which he had indicated could be attempted, it was necessary that the direction in which the meteors enter the earth's atmosphere should be known much more accurately than it then was, in order to enable astronomers to compute the *exact* forms and positions of the five possible orbits. This observation, then, was of the greatest importance in 1866, and it was on this account that all the astronomers on that occasion devoted nearly all their efforts to determining with the utmost precision the exact point of the constellation Leo from which the meteors seemed to radiate. This important direction was ascertained during the great meteoric shower on the morning of the 14th of November, 1866, and immediately after Professor Adams and his two assistants in the Cambridge Observatory set to work at their arduous task. This great calculation required the solution of a problem in mechanics which had never before been attempted, and involved an immense amount of tedious labor. Amid all these difficulties Professor Adams triumphed; and after months of toil he was able to announce in the following March that, if the meteors are moving in the large orbit, Jupiter would produce a shifting of the orbit in each revolution amounting to 20′, the attraction of Saturn

would add to this 7′, Uranus would add 1′; the effect of the earth and other planets would be insensible. Adding these numbers together, the whole effect, according to Mr. Adams's computation, is 28′, almost exactly the same as the observed amount which had been determined by Professor Newton, which was 29′. But, if the meteors were in any of the other four possible orbits, the total amount would never exceed 12′. Here, then, we have reached the final result: *the long orbit is the orbit of the meteors.* This great discovery was published in March, 1867.

Meanwhile Signor Schiapparelli, of Milan, was laboring in another direction. It was evident from the observations that the meteors were drawn out into a long stream. What was the cause of this? Signor Schiapparelli pointed out that if a cloud of meteors were started under conditions which are not quite the same, each meteor would pursue its own orbit, which would differ from the others. If they were treated almost exactly, although not quite, alike at starting, their various orbits would lie excessively close to one another, and would be undistinguishable in most respects. But if there be any effect which goes on accumulating from revolution to revolution, such an effect would in the end become very sensible. And such an effect there is. The periodic times differ a little in these different orbits. At the end of the first revolution those meteors which have the longest periodic times are the last to get back to the starting-point, and have, therefore, already fallen a little into the rear of the group, while those with the shortest periodic time have gone a little ahead. At the end of the second revolution the separation is doubled, and in each successive revolution the column is still more lengthened out. After a sufficient number of revolutions it will be spread out over the whole length of the orbit, and form a complete oval ring. This has not yet happened to the November meteors, and we are thus assured that it can not be any enormous period, speaking cosmically, since the time when they first started on their present path. On the other hand, the August meteors, which have returned punctually *every* year since they were first observed, are probably a complete ring, and are at all events of far greater antiquity than the November meteors. But they are also, as might be expected, more scattered, so that the sprinkling of meteors they discharge upon the earth as it passes through them has nothing like the splendor of the great November shower. Signor Schiapparelli also pointed out that there is a comet moving in the track of the August meteors, and another in the track of the November meteors. We shall presently see the significance of this observation.

The next great step was made by M. Le Verrier, the late Director of the Paris Observatory. Acting on the suggestion made by Signor Schiapparelli, M. Le Verrier pointed out that the orbit of the meteors intersects the orbit of Uranus, as represented in the diagram. From

its inclined position it does not intersect the path of any of the intermediate planets Saturn, Jupiter, and Mars. M. Le Verrier also calculated back the epochs at which the planet and the meteors were at the point of intersection, and found that early in the year A. D. 126 they were both at that spot, but that this has not happened since. Taking this in conjunction with what Signor Schiapparelli pointed out, we seem to have a clew to a truly wonderful past history. All would be explained if we may suppose that, before the year 126, the meteors have been moving beyond the solar system; and that in that year they chanced to cross the path of the planet Uranus, traveling along some such path as that represented in the diagram. Had it not been for the planet, they would have kept on the course marked out with a dotted line, and, after having passed the sun, would have withdrawn on the other side into the depths of space, to the same measureless distance from which they had originally come. But their stumbling on the planet changed their whole destiny. Even so great a planet would not sensibly affect them until they got within a distance which would look very short indeed upon our diagram. But they seem to have almost grazed his surface, and, while they were very close to such a planet, he would be able to drag them quite out of their former course. This the planet Uranus seems to have done, and when, pursuing his own course, he again got too far off to influence them sensibly, they found themselves moving slowly backward, and slowly inward; and accordingly began the new orbit round the sun, which corresponds to the situation into which they had been brought, and the direction and moderate speed of their new motion.

They seem to have passed Uranus while they were still a small, compact cluster. Nevertheless those members of the group which happened to be next the planet as they swept past, would be attracted with somewhat more force than the rest, the farthest members of the group with the least. The result of this must inevitably have been that, when the group were soon after abandoned to themselves, they did not find themselves so closely compacted as before, nor moving with an absolutely identical motion, but with motions which differed, although perhaps very little, from one another. These are conditions which would have started them in those slightly different orbits round the sun, which, as we have seen, would cause them, as time wore on, to be drawn out into the long stream in which we now, after seventeen centuries, find them.

What is here certain is, that there was a definite time when the meteors entered upon the path they are now pursuing; that this time was the end of February or beginning of March in the year 126 is still a matter of probability only. It is, however, *highly* probable, because it explains all the phenomena at present known; but astronomers are not yet in a position to assert that it is ascertained, since one link in the complete chain of proof is wanting. We who live now should be

in possession of this link if our ancestors had made sufficiently full observations ; and our posterity will have it when they compare the observations they can make with those which we are now carefully placing on record for their use. They will then know whether the rate at which the stream is lengthening out is such as to indicate that A. D. 126 was the year in which this process began. If so, Le Verrier's hypothesis will be fully proved.

Another episode in the eventful history of these meteors is also known with considerable probability. It has been already mentioned that a comet is traveling along the same path as the meteors. It is moving a very little slower than they, and is at present just at the head of the procession which they make through space. Another comet is similarly moving in the track of the great elliptic ring of August meteors. In 1867 the lecturer ventured to suggest an important function which these comets seem to have discharged. Picture to yourselves a mass of gas before it became connected with the solar system, traveling through space at a distance from the sun or any other star. Meteors would now and then pass in various directions, and with various velocities, through its substance. For the most part they would go entirely through and pass out again ; but in every such case the meteor would leave the comet with less velocity than it had when approaching it. And in some cases this reduced velocity would be such that the future path of the meteor would be an ellipse round the comet. Whenever this was once brought to pass, the meteor would inevitably return again and again to the comet, each time passing through some part of its substance, and at every passage losing speed. After each loss of speed the ellipse it would next proceed to describe would be smaller than the one before, until at last the meteor would sink entirely into the gas and be ingulfed by it. In this way meteor after meteor would settle down through the comet, and, in the end, just such a cluster would be formed as came across the planet Uranus in the year 126, or, if such a cluster existed originally within the mass of gas, it would in this way be augmented. As the comet swept past the planet, its outlying parts would seem to have grazed his surface, and in this way the gas was probably somewhat more retarded than the meteors ; and in the centuries which have since elapsed the meteors have gone so much ahead of the comet that they are now treading on his heels and on the point of overtaking him, while probably the gas has again brought together a smaller cluster of the meteors.

The question now arises, How the deserts of space which extend from star to star come to be tenanted here and there by a patch of gas or an occasional meteorite? Light has been thrown on this inquiry by discoveries made with the spectroscope in modern times and by observations during eclipses. These have revealed to us the fact that violent outbursts occur upon the sun, and doubtless on other

stars, so swift that the up-rush must sometimes carry matter clear away into outer space. Imagine such a mass consisting in part of fixed gas and in part of condensable vapors ejected from some star. As it travels forward the vapors cool into meteorites, while the fixed gas spreads abroad like a great net, to entangle other meteors. In some cases both might travel together; in others the gaseous portion would be retarded before it passed beyond the neighborhood of the star, and the denser meteors would get ahead. But even so in the lapse of ages other meteors would be caught, so that in any event a cluster would at length be formed. Now, the reasonable suspicion that this is the real origin of meteors has received striking confirmation from the discovery of the late Professor Graham, that meteoric iron contains so much hydrogen occluded within it as indicates that the iron had cooled from a high temperature in a dense atmosphere of hydrogen—precisely the conditions under which the vapor of iron would cool down while escaping from a large class of stars, including our sun.

We have now traced an outline of the marvelous history of these Arabs of the sky. We have met with outbursts upon stars sometimes of sufficient violence to shoot off part of their substance. We have found the gaseous portion sweeping through space like a net, and the vapors that accompanied it condensed into spatters that have consolidated into meteorites. We have seen this system traveling through boundless space, with nothing near it except an occasional solitary meteor, and we have seen it in the long lapse of ages slowly augmenting its cluster of these little strangers. As it wandered on it passed within the far-spreading reach of the sun's attraction, and perhaps has since been millions of years in descending toward him. Its natural course would have been to have glided round him in a curve, and to have then withdrawn to the same vast abyss from which it had come; but, in attempting this, it became entangled with one of the planets, which dragged it out of its course and then flung it aside. Immediately, it entered upon the new course assigned to it, which it has been pursuing ever since. After passing the planet the different members of the group found themselves in paths very close to one another, but not absolutely the same. These orbits differed from one another very slightly in all respects, and among others in the time which a body takes to travel round them. Those meteors which got round soonest found themselves, after the first revolution, at the head of the group; those which moved slowest fell into the rear, and the comet was the last of all. Each succeeding revolution lengthened out the column, and the comet soon separated from the rest. Fifty-two revolutions have now taken place, and the little cloud has crept out into an extended stream, stretching a long way round the orbit, while the comet has fallen the greater part of a revolution behind. We can look forward too, and see that in seventeen centuries more the train

will have doubled its length, and that ultimately it will form a complete ring round the whole orbit. When this takes place, a shower of these meteors will fall every year upon the earth, but the swarm will be then so scattered that the display will be far less imposing than it now is.

Such is the history of one of the many meteoric streams which cross the path of the earth. There are several of these streams, and no doubt the story of every one of them is quite as strange. And if there are several streams of meteors, which come across that little line in space which constitutes the earth's orbit, what untold multitudes of them must be within the whole length and breadth of the solar system! Perhaps it may even turn out that the mysterious zodiacal light which attends the sun is due to countless hordes of these little bodies flying in all directions through the space that lies within the earth's orbit.

THE RE-EDUCATION OF THE ADULT BRAIN.

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MRS. H——, the subject of the following case, is about twenty-four years of age,* of a pale complexion and slender make. She was married in July, 1823, and, with the exception of occasional headaches to which she, in common with some of the rest of her family, was subject, and slight bowel complaints, she previously to that time enjoyed good health, both of body and mind. After her marriage she resided in England till the end of April, 1824, when, in consequence of ill health, she was brought here by her husband, on a visit to her friends who live in this neighborhood,† and with whom she had passed a great part of her previous life. From her husband's account, it appeared that for about three months after their marriage she enjoyed perfect health and spirits, but that after that time she complained a good deal of pain in her stomach and bowels; her appetite was bad, she began to lose spirits, imagining herself unequal to the concerns of the house, though her family consisted only of herself and her husband; and now also it was observed that she slept more than usual. The medical gentlemen consulted, believing some of her complaints might be owing to an affection of the liver, administered mercury in small quantities and applied leeches to the temples in considerable numbers, with a view to relieve an uneasy feeling of lightness which she complained of in her head; but these remedies proved of little or no avail, and for some time before leaving England, excepting a laxative which she

* This was written in 1824.

† Arbroath, Forfarshire.

took twice a week, she had given up the use of medicine altogether. No probable cause could be assigned for these complaints.

On her arrival in this place, which, as already mentioned, was about the end of April last, she had lost but little flesh, and by no means looked sickly; indeed, she was little, if at all, changed in her appearance; all her external senses were sound, but her memory was impaired, and she was very inattentive to surrounding objects, which made her dull and absent in company. The sleepiness had been very gradually increasing, and was now arrived at such a height that, unless when conversing with another person, or engaged in some manual occupation, she fell asleep at all times, and in whatever situation or position she might be. When in this state her eyes were nearly closed, she breathed softly, and, in short, very much resembled a person in natural sleep, except that when she happened to fall asleep in a position in which the body naturally requires to be supported, as for instance on a chair, she did not lean forward or backward as is commonly the case, but sat with her body quite erect, and her head gently inclined to one side. While in this state she was subject to frequent startings, during which she raised herself up, talked as if she were frightened, drew herself back as if to avoid something disagreeable, and then after a few seconds lay quietly down again without having waked. What she said on these occasions, though quite incoherent, was yet always nearly of the same nature, and for the most part consisted even of the same expressions, which were those of great aversion or horror; of this she had no recollection when awake, nor of anything connected with it; and she herself remarked as something extraordinary that now she did not dream, although she used formerly to be very subject to dreaming. From this sleep she never awoke of her own accord, except to obey the calls of nature; and there was no other way of rousing her up upon other occasions, but by placing her on her feet and endeavoring to make her walk. When thus forcibly awakened, she was fretful, and cried for some time after. She took food in sufficient quantity, and often with evident relish; but it required much entreaty to make her take the first two or three mouthfuls. The pulse varied a little, but on the whole was nearly natural; during sleep it was commonly from fifty-six to seventy, and somewhat more when awake. Her bowels were very costive, and constantly required the use of laxative medicine; the discharge of urine was natural; the catamenia had hitherto been regular in their appearance, but in small quantity. She complained of no pain or other uneasiness, except a peculiar feeling in the top of the head across the bregma, which she called "funny."

For five weeks after her arrival the torpid state and indifference to surrounding objects continued gradually to become worse, and the difficulty of awakening her daily increased; till at length, about the 8th or 10th of June, it was found impossible to rouse her up at all by

any means that could be thought of; and from that time forth, excepting a few short intervals, she remained in a state of constant sleep till the beginning of August. Her condition was now singular enough. She still made an attempt to get out of bed when she required to go to stool; when food was presented to her lips with a spoon, she readily took it into her mouth and swallowed it, and in this way she was fed as long as the torpor continued; when she had taken what appeared a sufficiency, she closed her teeth as a sign she was satisfied, and if importuned to take more, turned away her mouth from the spoon. She appeared also to distinguish different tastes, for she gave an evident preference to some sorts of food and obstinately refused others. She sometimes even, to all appearance, judged of the nature of the food or medicines offered to her, by the sense of smelling; and, when the latter were such as possessed a strong odor, she would often close her mouth in a determined manner before they touched her lips.

By this time the startings in her sleep had left her; and although the expressions she uttered when in that state were, with some slight additions, nearly the same as formerly, yet her manner of speaking was now indicative of satisfaction and not of fright. She often even sang to a simple but cheerful air nearly the same words which she used formerly to cry out with every appearance of the greatest terror.

The torpor continued nearly in the same degree till the end of July, with occasional intervals of waking, which happened at uncertain periods, but generally at the distance of a few days from each other, and were occasioned by pain experienced in some part of her body. The first of these took place after she had been ten days in a continued state of torpor; it was caused by severe griping from laxative medicine. She awakened in great suffering, crying out, "Pain! pain!" "Die! die!" and placing her hands on the abdomen. She was relieved by means of warm fomentations; but she, notwithstanding, kept awake for some hours after, during which time she answered no question, in however loud a voice it was put to her, and recognized nobody except one old acquaintance, whom she had not seen for more than twelve months. She looked steadfastly in this person's face for a few seconds, apparently occupied in trying to remember his name, which at length she found out and repeated again and again, at the same time taking him by the hand as if overjoyed to see him; but when questioned regarding him, she answered only by calling out his name, which she continued to repeat for some time after she had fallen asleep, in addition to what she usually said. In the course of the next eight days she was twice roused from her sleep by a similar cause, but not so completely; the same individual was still the only person she knew; among others she did not recognize even her own husband, who happened then to be in Scotland.

The next interval of waking took place three or four days afterward; it appeared to be occasioned by pain in the head. She cried

for some time, then awoke, complaining of pain, with her hand on the fore part of her head, on which also she placed the hand of a person near her and pressed it down firmly with her own; after thus complaining for two or three hours, she fell asleep. The same thing happened on the next and the two or three succeeding evenings, nearly at the same hour, but each time with less complaint. Other circumstances about this time showed that she was suffering considerable uneasiness in her head. She was very impatient in the erect posture, and, when lifted out of bed, would not put her feet to the ground, but drew up her legs to her body, as if to force those who held her to lay her down again. This, however, was not the case when she required to be taken up for the purpose of making any evacuation. She generally also preferred to lie on her face, and always with her head very low, with both hands firmly clasped over it, exactly on the part to which she had formerly referred the peculiar feeling already mentioned, and showed much uneasiness when they were removed, unless the pressure was continued by the hand of another person.

After this, the torpor continued for some time without being interrupted; but in the mean time the symptoms of pain in the head, and the uneasiness in the erect posture, gradually wore off, and Mrs. H—— now no longer talked in her sleep. Her bowels were kept open by laxative medicine, which now did not operate so severely as to wake her. She had, since the beginning of June, had a blister applied to the nape of the neck, and three to the head at different periods; sinapisms to the feet were also had recourse to, and two or three times electric shocks were passed through her arms. These remedies, like other painful stimulants, caused her to complain much; and one of the blisters, which was sufficiently large to cover the whole scalp, made her open her eyes; but their effects were merely temporary, leaving, to all appearance, no permanent impression on her complaint. Lest there might be any serous effusion within the cranium, digitalis was used along with the sweet spirit of niter, in such quantity as greatly to augment the flow of urine. By its operation her pulse was reduced so low as forty-four in a minute; and, while using it, she appeared to suffer from sickness at the stomach, during which she often put her fingers into her mouth, as if wishing for something to eat or drink; and she was subject to what seemed an oppressive feeling in the region of the heart, with a peculiar interruption to her breathing, which came in paroxysms; all which symptoms left her after discontinuing the medicine.

Toward the latter end of July, the torpid state, which had suffered no more intermissions, was become on the whole not quite so deep; at least Mrs. H—— now gave signs of being more conscious of anything that was done to her. She smiled and seemed pleased on receiving particular sorts of food, and when her eye was opened, or any part of her face touched with a finger, her whole countenance became suffused with

a blush of redness. Some short time after, it became possible to awake her by opening her eyes, and holding anything before them likely to catch her attention, such as a glass of water, a cup, or the like. When awakened in this way, which succeeded best at the times she was getting her food, she generally laughed a good deal and seemed much delighted, and she always bestowed her whole attention on the vessel in which her food or drink was contained, and the person who held it; she, however, did not speak, and paid no attention whatever to the questions put to her. One day about this time, viz., on the 1st of August, in consequence of her usual medicines failing in their effect, she had two or three laxative clysters, and then a small dose of croton-oil, which produced very copious evacuations, but at the same time caused so much griping as to wake her. When suffering from this, she took hold of the blankets of her bed, twisted them in her hands, and applied them over the abdomen, looking wistfully all the while in the faces of the attendants, as if she had recollected the fomentations which had formerly given her relief, and wished them to be had recourse to on the present occasion ; her wish was complied with, with the effect of removing the pain, which seemed to give her great satisfaction. In two or three days after this the torpor was much diminished, and she could be awakened with great ease. She likewise began to take a great liking to the young woman who waited on her, so much so that, when awake, she would hardly allow her to be a moment out of her sight. Now also she would sometimes let herself cautiously down on the floor from her bed, and creep to the fireside, where she would lay herself quietly down on the hearth-rug, as if she wished to enjoy the warmth of the fire.

At length, after progressively improving for some days, she was by the third week in August almost free from torpor, and slept little more than a person in health. During all this period, except that her feet were sometimes cold, the temperature of her body was very nearly natural. Her face was for the most part pale, but sometimes a little flushed, and the pupil of the eye uniformly contracted on exposure to the light. Her pulse, which had been rendered slow by the digitalis, was observed to be rather higher for some time preceding her recovery than it had been even before the use of that medicine. She had undoubtedly lost flesh during her illness, but at this time she was not so thin as she had been a short time before. The catamenia had not appeared since the month of May ; but, with the exception of considerable loss of strength, her bodily health was now on the whole tolerably good.

On her recovery from the torpor she appeared to have forgotten nearly all her previous knowledge ; everything seemed new to her, and she did not recognize a single individual, not even her nearest relatives. In her behavior she was restless and inattentive, but very lively and cheerful ; she was delighted with everything she saw

or heard, and altogether resembled a child more than a grown person.

In a short time she became rather more sedate, and her attention could be longer fixed on one object. Her memory too, so entirely lost as far as regarded previous knowledge, was soon found to be most acute and retentive with respect to everything she saw or heard subsequently to her disorder; and she has by this time recovered many of her former acquirements, some with greater, others with less facility. With regard to these, it is remarkable that though the process followed in regaining many of them apparently consisted in recalling them to mind with the assistance of her neighbors, rather than in studying them anew, yet even now she does not appear to be in the smallest degree conscious of having possessed them before.

At first it was scarcely possible to engage her in conversation; in place of answering a question she repeated it aloud in the same words in which it was put, and even long after she came to answer questions she constantly repeated them once over before giving her reply. At first she had very few words, but she soon acquired a great many, and often strangely misapplied them. She did this, however, for the most part in particular ways; she often, for instance, made one word answer for all others, which were in any way allied to it; thus in place of "tea," she would ask for "juice," and this word she long used for liquids. For a long time also in expressing the qualities of objects, she invariably, where it was possible, used the words denoting the very opposite of what she intended. And thus she would say "white" in place of "black," "hot" for "cold," etc. She would often also talk of her arm when she meant her leg, her eye when she meant her tooth, etc. She now generally uses her words with propriety, although she is sometimes apt to change their terminations, or compose new ones of her own.

She has as yet recognized no person, not even her nearest connections; that is to say, she has no recollection of having seen or known them previously to her illness, though she is aware of having seen them since, and calls them either by their right names or by those of her own giving; but she knows them only as new acquaintances, and has no idea in what relation they stand to herself. She has not seen above a dozen people since her illness, and she looks on these as all that she has ever known.

Among other acquirements she has recovered that of reading; but it was requisite to begin her with the alphabet, as she at first did not know a single letter. She afterward learned to form syllables and small words, and now she reads tolerably well, and has shown herself much interested in several stories previously unknown to her, which she has read since her recovery. The reacquisition of her reading was eventually facilitated by singing the words of familiar songs, from the printed page, while she played on the piano. In learning to write she

began with the most elementary lessons, but made much more rapid progress than a person who had never before been taught. Very soon after the torpor left her, she could sing many of her old songs, and play on the piano-forte with little or no assistance ; and she has since continued to practice her music, which now affords her great pleasure and amusement. In singing, she at first generally required to be helped to the first two or three words of a line, and made out the rest apparently from memory. She can play from the music-book several tunes which she had never seen before ; and her friends are inclined to think that she now plays and sings fully as well, if not better, than she did previously to her illness. She learned backgammon, which she formerly knew, and several games at cards with very little trouble ; and she can now knit worsted, and do several other sorts of work ; but with regard to all these acquirements, as already mentioned, it is remarkable that she appears not to have the slightest remembrance of having possessed them before, although it is plain that the process of recovery has been greatly aided by previous knowledge, which, however, she seems unconscious of having ever acquired. When asked how she had learned to play the notes of music from a book, she replied that she could not tell, and only wondered why her questioner could not do the same.

She has once or twice had dreams, which she afterward related to her friends, and she seemed quite aware of the difference between a dream and a reality ; indeed, from several casual remarks which she makes of her own accord, it would appear that she possesses many general ideas of a more or less complex nature, which she has had no opportunity of acquiring since her recovery.

In this way she has continued slowly but progressively to improve, and it is now considerably more than two months since she recovered from her sleep. Her bodily health has since then undergone little change : she is still liable to be fatigued by slight exertion, after which she is inclined to sleep ; but in this state she never remains long except during the night, when she sleeps like another person. The catamenia have twice appeared, viz., in September and in October, at both times to a greater extent than usual ; her bowels still require laxative medicine ; but her appetite continues good, and she has evidently gained flesh since her recovery.

Postscript (*March*, 1879).—After a time Mrs. H—— was able to return to her home in England, where she passed the rest of her life happily with her husband, and gave birth to a daughter, who survives her. She was in the habit of corresponding by letter with her friends at a distance, and lived on the most agreeable terms with her immediate neighbors, by whom she was held in much regard on account of her kindly nature and charitable work.—*Brain.*

THE MOLECULAR THEORY.*

By LE ROY C. COOLEY, Ph. D.

THE idea that matter is an aggregate of minute particles, each of which possesses all the essential properties of the mass, is as old as Democritus, but it was left for the present century to crystallize the conception of the atom in clear and accurate expression. The atomic theory, revived and vitalized by the illustrious Dalton, has not simply been able to survive the conflicts in which many an older theory has been wrecked: it has itself been a prime mover of revolutions. It is doubtful whether without it the recent advances in chemical and physical science could have been made.

But the atom in chemistry is not the atom in physics; they are of a different order. When the idea of a chemical atom came to be clearly conceived so that atom could be defined, as it is, to mean the smallest particle of an elementary substance which can enter into the composition of a compound, the most natural, if not, indeed, the inevitable corollary would be that the compound itself must be made up of parts, each of which, containing only the minimum number of its constituent atoms competent to give it character, must be the smallest particle of that substance which can possibly exist. To distinguish this minutest portion of a substance from the chemical atoms of which it is composed, the French called it the *molecule*—literally the little mass; and this word molecule, homeless in the English language less than one hundred years ago, expresses an idea which now lies at the foundation of modern physics.

It has been said that the science of astronomy is the demonstration of the law of gravitation. Indeed, what evidence have we of the truth of Newton's grand generalization, except that it explains the phenomena of the skies? So, in the outset, we may say that the science of physics is the demonstration of the molecular theory of the constitution of matter, since it explains phenomena, suggests research, directs experiment, classifies and unitizes wide ranges of apparently diverse results, to an extent unparalleled by any other.

This theory boldly affirms a limit to the divisibility of matter, and thus seems to defy the logic of the metaphysician, who, passing the limit set by the necessary imperfections of manipulation, carries the process of subdivision mentally downward through the scale of littleness, until, finding no place where his conception of subdivision must halt, declares that no limit exists. But the physicist does not deny the logic of the metaphysician; he simply remembers that mental conceptions need not of necessity represent the realities of nature's processes,

* Read before the Poughkeepsie Society of Natural Science, December, 1878.

in the subdivision of matter. He claims that the line which may be mentally thrust through the minutest particle of matter is not a needle nor a knife—that it is the mathematician's line as immaterial as space—and that the thrusting of such a line can accomplish no division. He claims that, applicable as it may be to space, such logic need not bind the physicist who studies the constitution of bodies which inhabit space.

Therefore, unconcerned about the abstract question of divisibility, the physicist anxiously inquires whether the phenomena of the material world can afford any testimony in regard to the ultimate constitution of bodies. And the molecular theory may be regarded as an induction from a multitude of observed facts—a generalization reached by a careful comparison of many established principles. The object of the present paper is to present the theory in this light. To exhaust the evidence, however, by this method would be to present the science of modern physics complete, a task impossible at a single sitting.

The three fundamental conceptions embodied in the molecular theory are: the existence of molecules, the existence of molecular spaces, and the existence of molecular motions.

Now, there may be phenomena which declare the existence of molecules without touching the question of molecular space or of molecular motion, and proofs both of the existence of molecules and of molecular spaces may be altogether silent on the question of rest or motion. But notice: whatever evidence we have of the existence of intervals between the ultimate parts of a body is equally evidence of the existence of molecules, and whatever phenomena indicate the existence of motion among these interior parts of a body do equally affirm the existence both of molecules and of molecular spaces. If, then, the three classes of phenomena be presented as bearing first upon the molecule, second upon molecular spaces, and third upon molecular motion, the testimony will be continuous and cumulative.

First, then, as to the existence of molecules. We will confine our attention to two sources of evidence—the phenomena of divisibility and of chemical synthesis.

Is it possible, by continued subdivision, to reach a particle the division of which would put an end to the existence of the substance—not in the sense of annihilation, but, in other words, to reach a particle whose division compels a substance to suffer death by yielding up those identifying properties by which alone we distinguish it from other kinds of matter?

A piece of marble may be crushed and reduced to an almost impalpable powder, and yet, on examination, each little grain is found to be an angular block of stone, lacking no property of the original block except its size and form. The same may be said of other solids. Even ice, keep its temperature low enough, may be reduced to microscopic fineness, and each little particle, notwithstanding its minuteness,

will be a block of ice. Nay, more; when by such mechanical means subdivision can be carried no further, we may resort to a gentle heat and find these microscopic blocks crumbling into fragments finer still; for what is melting but a process of division? In it, particles simply fall apart because the ties of cohesion are sundered by the heat, and the liquid is the same substance, differing from the impalpable powder only in the mobility due to its finer state of division. Now touch the liquid with a somewhat intenser heat. We find that the water is converted into steam, becoming invisible, and that the water-gas occupies a volume seventeen hundred times larger than did the water which it represents. However remarkable this change, yet it does not touch that which gives character to the substance. In all its essential properties it is water still. Furthermore, not the slightest addition or subtraction has been made. The process, in all its steps, from the original block of ice to the seventeen-hundred-fold volume of invisible vapor, is simply a process of division.

Now endeavor to carry the subdivision further. It may be that a fiercer heat will be a keener edge to cleave the invisible particles of water-gas. Thanks to Professor Chandler, who has taught us how to apply the requisite heat without at the time introducing a chemical attraction, so that we may be left confident that, whatever the result, it is accomplished by the same agents by which our previous subdivisions have been made.

In this experiment the steam is passed into a platinum flask, which is kept red-hot. From this flask a delivery tube conveys it to a jar designed to receive the products of the experiment. The invisible steam enters the platinum flask; an invisible gas also passes onward to be caught in the receiver; but afterward, on bringing a flame to the mouth of this receiver, an explosion declares that its contents are water-gas no longer—that a mixture of hydrogen and oxygen has taken its place. The steam particles are evidently broken by the heat. But mark the result: the fragments are no longer particles of water. The red heat has dissected the steam particles, and revealed the fact that they consist of still smaller pieces of hydrogen and oxygen.

In the form of steam, therefore, water is in its finest possible state of division, for to divide it further is to compel it to cease to exist as water. We are therefore entitled to declare that this substance consists of ultimate particles, which can not be divided without changing them into other kinds of matter. These are its *molecules*. Next, in the light of chemical synthesis, also, we may see the existence of these ultimate particles.

Hydrogen and oxygen are the inevitable constituents of water, and two volumes of hydrogen to one volume of oxygen are the invariable proportions. No human agency can obtain water by combining any other elements, nor by combining these in any other proportions.

These are facts confirmed by all experience. Nevertheless, it mat-

ters not how little oxygen is taken, provided only that the proper proportion of hydrogen is supplied. Then let us conceive the least possible portion of oxygen. Let the mind wrestle with the conception and reduce the volume of this gas until it is fixed at the smallest that can take part in a chemical action. Then conceive it combined with a volume of hydrogen twice as great. We may contemplate the infinitesimal droplet of water so produced, but to conceive a droplet any smaller is impossible, since this one contains no more than the least possible portions of its elements. To break this droplet of water would be to reduce it to fragments of hydrogen and oxygen. Again, then, do we find our minds in the presence of particles which can not be divided except at the sacrifice of their identity—in other words, in the presence of *molecules*.

But if molecules exist, the second question at once arises, Are they so closely packed as to constitute a continuous mass, or are they separated by intervening spaces?

A second class of phenomena directs our judgment here. We might detail the mathematical investigation by Cauchy, a third of a century ago, by which he demonstrated the impossibility of the dispersion of light in a substance whose minutest parts are absolutely homogeneous. It was proved that dispersion happens only on condition that "two contiguous portions of the medium, whose dimensions are moderately small fractions of a wave-length of light, are dissimilar." The molecules with intervening spaces would realize such dissimilarity.

But, confining ourselves to the experimental side of the problem, we find a variety of familiar phenomena ready to bear witness to this structure. Among them are porosity, expansion and change of physical condition, and the diffusion of vapors.

In regard to porosity, an old and homely experiment will give us a starting-point. We take a tall and narrow glass jar and fill it so completely with alcohol that the addition of a single drop will endanger an overflow. The jar appears to be full of a perfectly homogeneous liquor. But if a sheet of cotton wool, whose fibers have been previously well loosened, be at hand, fragment after fragment may, with care, be slowly introduced, without causing the overflow of a single drop, until the jar appears to be filled with moistened cotton instead of with alcohol. We have before us the surprising appearance of two bodies filling the same space at the same moment. Surely, however, we are not at liberty to adopt this explanation. For what should we call that which has no power to exclude another from the space which it occupies? To call it matter is to obliterate all distinction between matter and space. We are impelled to seek another explanation, and we find one more acceptable in the hypothesis that neither of the two bodies wholly fills the space which it appears to occupy—that spaces, too minute for even microscopic vision to detect, intervene between the ultimate particles of both, and to such an extent that these mate-

rial particles of each find a habitation in the spaces of the other. Moreover, this experiment is but one of a large class, which all alike present the appearance of two or more bodies existing at the same time in the same place. And this phenomenon is a symbol which, translated, declares the existence of intervening spaces between the ultimate parts of which bodies of matter are composed. In regard to expansion and change of form, one of the most familiar and universal effects is the expansion of bodies by heat, and the most obvious classification of material objects is into three physical forms—the solid, the liquid, and the gaseous. We have only to admit the existence of molecules and of molecular spaces, and expansion can be defined at once to be the enlargement of these spaces under the influence of a force which drives the molecules asunder. Moreover, since distance is known to control the influence of attraction, it is plain that the melting of a solid and the vaporization of a liquid would be the necessary consequences of increasing the molecular distances, until cohesion is, in the one case nearly, and in the second case altogether, overcome. The existence of matter in three physical forms, and its changes from one to another under the influence of varying temperature, here find a most happy explanation.

But there follows a most important inference. If the gaseous form of matter is due to the separation of its molecules, then how enormously must their distances asunder exceed the diameters of the molecules themselves! For example, a cubic inch of water becomes about seventeen hundred cubic inches of steam. If this increase of volume is due to the enlargement of molecular spaces, how small a fraction of the vapor volume can consist of the material molecules! Can any experiment be brought to our relief, and furnish any solid ground on which we may stand and check the theory by testing the truth of this consequence? In "The New Chemistry,"* its author gives the following elegant description of an experiment on the diffusion of vapors:

"We have here a glass globe, provided with the necessary mountings—a stopcock, a pressure-gauge, and a thermometer, and which we will assume has a capacity of one cubic foot.

"Into this globe we will first pour one cubic inch of water, and in order to reduce the conditions to the simplest possible, we will connect the globe with our air-pumps and exhaust the air, although, as it will soon appear, this is not necessary for the success of our experiment. Exposing next the globe to the temperature of boiling water, the liquid will evaporate, and we shall have our vessel filled with ordinary steam. If, now, that cubic foot of space is really packed close with the material which we call water—if there is no break in the continuity of the aqueous mass, we should expect that the vapor would fill the space to the exclusion of everything else, or at least would fill it with a certain

* By J. P. Cooke, Jr., "International Scientific Series," D. Appleton & Co.

degree of energy which must be overcome before any other vapor could be forced in. Now what is the case? The stopcock of the globe is so arranged that we can introduce into it an additional quantity of any liquid on which we desire to experiment without otherwise opening the vessel. If, then, by this means, we add more water, the additional quantity will not evaporate, provided the temperature be kept at the boiling-point. Let us next, however, add a quantity of alcohol, and what do we find? Why, not only that this immediately evaporates, but we find that just as much alcohol-vapor will be formed as if no steam were present. The presence of the steam does not interfere in the least degree with the expansion of liquid alcohol into alcohol-vapor. The only difference which we observe is that the alcohol expands more slowly into the aqueous vapor than it would into a vacuum. If, now that the globe is filled with aqueous vapor and alcohol-vapor at the same time, each acting in all respects as if it occupied the space alone, we add a quantity of ether, we shall have the same phenomena repeated. The ether will expand and fill the space with its vapor, and the globe will hold just as much ether-vapor as if neither of the other two were present; and so we might go on, as far as we know, indefinitely. There is not here a chemical union between the several vapors, and we can not in any sense regard the space as filled with a compound of the three. It contains all three at the same time, each acting as if it were the sole occupant of the space."

Now these experimental results find an explanation nowhere else but in the inference, previously made, that molecular spaces do exist, and that they are so relatively large that the molecules of each gas find, in the spaces between the particles of all the others, abundant room to manifest all their characters.

If, now, we turn from vapors to the examination of permanent gases, we find a kindred action. Moreover, it is an action which not only confirms our evidence of the existence of molecules and molecular spaces, but, as we shall see in the sequel, in addition thereto suggests an answer to this important question in the history of molecules—are they in motion or at rest?

Hydrogen gas is sixteen times lighter than oxygen. Let us bring the open mouth of an inverted jar filled with hydrogen down upon the open mouth of a similar jar filled with oxygen. By this means we obtain a single cylinder of gas, the lower half of which consists of the heavier oxygen, and the upper half of the lighter hydrogen, the two gases being in contact only at their surfaces in the middle of the column. Their relative weights would lead us to expect them to maintain these positions; but the well-known properties of these gases enable us to learn that they do not. Neither one alone is explosive; their mixture is. Now, after a time, if we separate the jars and bring a flame to the mouth of the lower one, and then to the mouth of the upper one, two successive explosions occur, declaring that both jars

contain a mixture of the gases. What must have happened? Evidently a portion of the heavier gas has risen into the upper jar, and a portion of the lighter gas has fallen into the lower jar, and this too, notwithstanding the fact that their difference in weight is more than a third greater than that of lead and water. A further study of this phenomenon reveals the significant fact that just as much of each gas diffuses into the space of the other as would expand into a vacuum of the same size. In fact each gas is, at all temperatures, a vacuum to every other. This fact remains an unsolved mystery, except we admit the existence of molecules and of molecular spaces far outmeasuring the molecules themselves.

Vapors and permanent gases are, therefore, not unlike in this respect. But when we compare this diffusion of the latter with the production and commingling of the former, as shown in the globe experiment, we discover this difference: whereas the molecules of the vapor are driven into mixture by the application of heat, those of the permanent gases spring spontaneously each into the spaces of the other without it. Plainly there exists among the molecules of the gases at low temperature an energy to drive them asunder, such as must be introduced by artificial means among those of vapors to enable them to manifest the same action in the same degree. We need to say, "in the same degree," for even liquids do spring into the gaseous form and mingle their vapors with other gases at common temperatures. This is evaporation. And when we remember, further, that many solids, notably ice, camphor, iodine, yield vapors to the atmosphere on similar exposure thereto, we can feel justified in saying that there exists in gaseous and liquid and solid bodies alike an energy by which their molecules are urged asunder.

This molecular energy bears the closest relationship to heat. Of this the facts already stated are sufficient evidence. Every variation in one is accompanied by a corresponding variation in the other. Whenever heat is expended this molecular energy in the body receiving it is increased. Whenever a body of gas, freed from opposing pressures, expands, in obedience to this molecular agency, its own temperature is reduced. Moreover, the most exact quantitative relation can be traced. This molecular energy and heat are, therefore, correlative. All this is suggested by the facts of expansion, vaporization, and diffusion. But I have no time to give even an outline of the classic researches of Rumford, Mayer, Joule, and others, which prove that heat and molecular energy is the energy of molecules in motion.

Molecules, molecular space, and molecular motions—these three conceptions stand as the modern translation of the symbols on which the facts in regard to the constitution of matter are written. According to the theory, in every material body these three fundamental elements are embodied. It consists of particles which can not be divided without changing the nature of the substance, separated by distances in

comparison with which their own diameters are sometimes as insignificant as are the diameters of planets in comparison with their immense solar distances, and finally in motion, inconceivably rapid, and never ceasing. Such is the molecular theory of matter, in its most general form of expression. And in this form it seems destined to do for the science of physics what has been done for chemistry by the atomic theory, and for astronomy by the theory of gravitation. It seems competent to bring all branches into harmonious relation as constituents of a single science. It may do this even if the mathematical measurements of the magnitudes it describes should prove to be beyond the reach of human skill.

But, if molecules exist, what are their masses and their diameters? If they are not in contact, what isthe measure of their separation; and, if in motion, with what velocity? These are legitimate subjects of research suggested by the theory itself, and no less important in the science of physics than the problems of astronomical magnitudes are in astronomy. It is, therefore, not strange that the best intellects among experimental and mathematical philosophers should be found bending their energies toward the solution of these problems. Already very wonderful progress has been made, and numerical values are assigned to these molecular magnitudes, in some cases with great confidence in their accuracy, and in other cases provisionally, awaiting better and more extended means of research. For example, Dr. Joule tells us that the hydrogen molecule is darting through the molecular spaces of this gas at the rate of 6,099 feet a second; and Clerk Maxwell, that the molecules of oxygen move at the more sluggish rate of about 1,525 feet a second. We are further informed that the distance from center to center of the molecules of a gas is probably about $\frac{1}{800000}$ of an inch. Different methods of investigation agree tolerably well in pointing to $\frac{1}{30000000}$ of a millimetre as a fair approximation toward the diameter of a molecule—that is to say, about 760,000,000 of these bodies lying side by side would bridge the space of a single inch.

These magnitudes are of an order which only modern science has ever asked the intellect of man to contemplate. The human mind thus discovers its position between two infinities. It is able, through the agency of the senses, to acquaint itself directly with a very limited range of phenomena, but, planting itself upon this little fragment of solid ground, it reaches into space, and by observations and by computations made upon them becomes acquainted with the infinitely great; while in the other direction it pierces the recesses of minute bodies, and by observations and computations there it becomes acquainted with the infinitesimal. The results attained in both directions are alike incomprehensible. Who can, for example, accurately conceive the distance described as 1,000,000 miles? Even he who has made the circuit of the world can not rely on this extended experience to enable him to see the beginning, middle, and end of 1,000,000 miles in

their true proportions. Yet this is a little more than the one-hundredth part of our distance from the sun, from which we get the light and heat on which our lives depend. What, then, shall we say of those sidereal spaces to measure which this solar distance is taken as the unit! The astronomer contemplates magnitudes and distances and motions expressed by figures of such vast array, that the power of enumeration is almost staggered, and our capacity to comprehend values is altogether overwhelmed by them. But let us reduce the unit of measure from the mile to the inch, and then let us take the reciprocals of these enormous values obtained by the astronomer in his study of the planetary composition of the universe, and we shall have before us the order of measurements which engage the attention of the physicist who studies the molecular composition of matter. If we are not dismayed by the one, let us not be by the other. In one case our conceptions are pictures in miniature; in the other they must be pictures enlarged. But it is no more difficult to picture the distance between two minute bodies, when measured by the hundred-millionths of an inch, than it is to picture it between two greater ones when measured by the hundred millions of miles. To comprehend the real magnitude is, in both cases, impossible, and our belief in the existence of either must depend on our faith in the infallibility of mathematical processes and on the observations upon which they are based. But granting the existence of such evidence to sustain it, neither can be called incredible, however it may transcend our comprehension, for credulity consists, not in believing, but believing without evidence.

NEUTER INSECTS.

By PHILIP WOOLF, M. D.

HOW the workers of many insects became sterile is an interesting question, though one difficult to answer. Those who believe in special creation solve this problem, as they solve so many other difficulties, by stating that insects are sterile because they were created sterile. The majority of educated persons, however, require to be convinced by some more tangible argument; the conclusion that things are because they are, having lost the only merit it ever possessed, the annihilation of thought.

To state the problem that all may understand it: there are many insects, as the bees, ants, wasps, and termites, that are divided into three castes, males, females, and workers; the latter are sterile, and it is asked how, according to modern theory, these workers can have arisen? It is said that, since they do not propagate their kind, no spontaneous variations can be produced for natural selection to work

on, and hence that there is no other explanation of their existence than that they are specially created—that is, created in opposition to law.

To simplify the initial inquiry, we will suppose that workers differ from females only in that they are not fertile, the secondary differences being reserved for discussion toward the end of this paper.

That a creature may develop, it is essential that it be supplied with a sufficiency of food. Even with human beings food is all-important; if with these a sufficiency of mineral ingredients be not assimilated, we have the disease called *rickets;* insufficiency of vegetable food will cause scurvy; insufficient nutriment dwarfs the body and mind generally. The growing body must have enough material out of which to elaborate tissue, or the tissue, muscle, nerve, bone, can not develop. Now let it be supposed there are two larvæ or grubs of the bee, which under similar conditions will reach similar degrees of development; further suppose that one larva, which may be called A, receives an over-abundance of food, while the other larva, which may be called B, receives a quantity of food just sufficient for its more important wants, what will happen? The larva A will reach its full development—it will be a queen-bee; the larva B, on the other hand, not having food enough for all its wants, and furthermore having within a given time to change its conditions, it must use the nutriment for the building up of its more important organs, must work it up into tissues and structures that are essential to all bees. Its head, body, legs, and wings must be perfected before its reproductive system; the individual must profit before the race; and, if the food is only sufficient for individual functions, the race functions must suffer, the reproductive system must remain in an incipient state.

This conclusion is no mere theory, for among the higher animals, and even with man himself, insufficient nourishment first produces its effects on the reproductive system. Loss of blood induces abortion; badly prepared or insufficient food decreases or entirely checks the production of offspring. The distinction first clearly formulated by Dr. Carpenter is now a commonplace of science: "There is a certain degree of antagonism between the nutritive and reproductive functions, the one being executed at the expense of the other. The reproductive apparatus derives the materials of its operations through the nutritive system, and is entirely dependent on it for the continuance of its functions. It may be universally observed that, when the nutritive functions are particularly active in supporting the *individual*, the reproductive system is in a corresponding degree undeveloped, and *vice versa.*"

With bees the effects produced by food are clearly shown: a larva which otherwise would turn into a neuter is supplied with a different kind of food and it is converted into a queen. Huber obtained queen-bees by placing some of the "royal food" in cells inhabited by the larvæ of workers. Kleine performed the same experiment, placed a portion

of the royal food on the inner margin of the worker cell and produced queens. With bees, then, we see that the neuter is only a female with the reproductive organs partially developed, a conclusion further enforced by the fact that the neuter sometimes even lays eggs which develop into the drone or male bee. In this case then, at least, it may be said that the fecundity or sterility of bees depends *almost* entirely on the nature of the food given to the larvæ. With the true ants also, the so-called neuter is only a partially developed female, although there are no recorded observations to show that the difference between the fertile and the infertile insect is due to difference in food.

To advance now a step further: insects, originally, were either male or female; there were no neuters. For reasons presently to be given, we conclude that the males of even social insects, in addition to the duty of fecundating the female, also undertook the duty of defending the nest against warlike intruders. It may be also safely concluded that originally the females of even social insects, in addition to the duties of maternity, also undertook the labors of building the nest and taking care of the young—customs that still prevail more or less with many insects. Thus, the females of the solitary bees, after impregnation, hybernate during the winter. With the warm days of spring they awaken, build their nests, and die. Among wasps a similar state of things obtains. When the winter approaches, the entire colony, with the exception of a few pregnant females, dies. In the spring these females begin building a new nest, laying eggs, and so producing an efficient corps of assistants to aid them in their future labors.

Supposing, then, that originally the females undertook most of the work now done by the neuters; supposing, also, that at the beginning of spring there are only a few females, or even one female, to commence the work of building the nest and feeding the future progeny. With many duties to perform, it is not unwarranted to conclude that some duties may not be completely performed. The immediate success of the colony depends, not so much on the number of males or of females, as on a body of efficient assistants. Now, when one or a few insects have to feed many, some of the larvæ receive an abundance, some barely a sufficiency of food; and, on the theory previously advanced, we may see how neuter insects arose. The fact that quality as well as quantity of food is essential to future fertility does not add to the difficulty, since, as it takes more time to produce the highly nutritious than the somewhat less nutritious food, the conditions are still the same. If efficient assistants could be produced at a less expenditure of labor and in a shorter time than females, a supposition countenanced by facts, natural selection begins to work. In a given neighborhood those insects which produce a corps of assistants soonest, and with least expenditure of labor, will stand a better chance of obtaining food—of surviving—than those insects which give the same amount

of attention to each larva, rearing them all into perfect insects—a benefit also accruing to the earlier hatched larvæ themselves, as they sooner reach maturity, and can thus obtain an abundance of food without rivalry. These earlier produced neuters have their reproductive systems only slightly less developed than egg-bearing insects ; but natural selection, acting on the *nurse*, will cause them to grow less and less. Reproductive organs that do not produce are of no use to their possessors ; and, as this slightly less developed but useless reproductive system would require more attention and more food from the fertile nurse than would those larvæ in which it was a mere rudiment, natural selection, by working on the instinct of the nurses, would modify, alter, or even suppress what was of no use. Or we may suppose that in the distribution of food to the larvæ the action is direct, some receiving such a minimum quantity of food that the reproductive organs remain rudimentary from want of material to build them up.

The necessity of producing offspring quickly in early spring would give rise to the instinct to feed the first produced brood of larvæ on food insufficient in quality, or in quantity, or in both. The eggs, then, first laid by the female would develop into neuters. Neuters being sterile females, they would inherit the instincts of true females when they in turn took charge of the young. Whatever may be the worth of this theory, it throws some light on the curious fact that with some insects, as the bees and ants, the sexes are produced at different times. With bees the queen first lays eggs which produce neuters ; then, at a later period, eggs producing males. According to Gould, the female of the *Formica sanguinea*—the red ant—lays eggs which will produce females, males, and workers at three different periods. That the habit is so is well known ; but on the theory here supported can not we see how the habit arose, and the reason why such a habit exists?

Thus far food alone has been supposed to affect the development of insects, but there are several secondary factors ; size of cell being one. Thus with the bee, the cell in which the queen is hatched is larger, differently formed, and in weight said to be equivalent to one hundred ordinary cells ; the cells from which emerge the males are also larger than the cells of neuters. Now, the extra labor necessary to produce these cells in founding a new colony, the extra labor in attending to the inmates, and the non-necessity of having males or females at this early stage of colonial existence, are other reasons why the first-laid eggs produce only neuters. At present and in this place these points can be only touched on ; in the future they will receive more elaboration.

If neuters have arisen in the manner suggested, how has their inflexibility of character been maintained? By natural selection modifying the instincts of the *nurse*. What at first arose through the incapability of one or several insects taking care of many insects, became through the action of natural selection, by the survival of those

insects which produced a given result with least labor to themselves, an established instinct. Further questions may be now asked: Why is it that any other insects besides neuters have been produced? As they can not propagate their kind, how have they become gifted with the instincts to take care of and to feed the young, provide food for the colony, build nests, etc.?

To the first question a sufficient reply is, that, if nothing but neuters were produced, there would be no insects. The other questions may be answered by an amplification of a statement already made. Neuters, as a rule, are sterile females; the exceptions to this will be considered further on; they inherit the instinct of females and perform their duties with the one exception of ovulation. To give a few details: Originally there were no neuters; and as females were numerous, each female would lay comparatively few eggs. How the neuters arose we have already seen; at first they were few, gradually increasing until they equaled and finally outnumbered the females. At the same time the labors of the female became more restricted; as they decreased in number they must, in order to keep up the colony, lay more eggs: as a result, the extra time devoted to ovulation was so much time taken from cell-building, nursing, etc. Applying this theory to facts, we can see why with the increase of neuters the duties of the queen-bee have grown less and less until they consist of nothing but ovulation. The queen-bee is a queen only in name, receiving just such extra care that her time may be entirely devoted to propagating the species. At such time when each hive only contained one reigning queen, this female had to assume the reproductive functions of her twenty thousand sterile sisters, and it is not strange that she has no time to build or to feed the young. Under no other conditions could she lay her two thousand to three thousand eggs a day. The case of the termites or so-called white ants is more striking, the female laying eighty thousand eggs in the course of a day, or very nearly one egg a second continuously. What other duties can this huge animated egg-sac perform?

With existing social insects, as a rule, the male does little or no work but that of fertilizing the females, but before the appearance of neuters we may suppose he had other duties. With many beetles the male performs a large share of the labor; the male of the burying beetle, for example, excavating the grave in which its prey is buried and in which the female deposits her eggs. With many insects the male defends the nest or burrow from the attacks of invaders, of which take an example quoted by Mr. Darwin in his "Descent of Man": "The two sexes of *Lethrus cephalotes* (one of the Lamellicorns) inhabit the same burrow. If during the breeding season a strange male attempts to enter the burrow, he is attacked; the female does not remain passive, but closes the mouth of the burrow and encourages her mate by continually pushing him from behind." That males are not always

passive, the work just quoted abundantly proves. Now when neuters are produced from males their duties differ from the neuters produced from females, and, as we have supposed that the duties now performed by sterile females were once performed by fertile females, so we may now conclude that the duties performed by sterile males were once performed by the perfect males. The worth of this conclusion will be presently seen.

The remaining difficulty is to account for the fact that with many insects the neuters differ considerably from the fertile insects. Thus, for example, with the termites or white ants; these are the perfect males and females, the soldiers, which are aborted males, and the workers, which are aborted females. The males and females have wings, the neuters are wingless; the workers undertake architectural duties, act the part of nurses, etc., while the soldiers defend the nest from attacks. Both workers and soldiers are blind, but whereas the workers have a somewhat circular head and small jaws, the soldiers have a comparatively enormous head, and strong resisting mandibles. In what manner then, or through what cause, could the head of this soldier termite differ so greatly from either that of the perfect male or perfect female? Or, since it is impossible in any given case to explain all the details satisfactorily, let it be asked how it is that so many neuter insects differ from their parents.

Neuters are either sterile males or sterile females, and in many cases do not differ greatly from their fertile progenitors; the social bees and wasps are examples of this. On the theory advanced, it has been supposed that originally the neuter differed only from the perfect insect in that it had a rudimentary reproductive system. Now, suppose, to take an imaginary example, that in a colony of ants there are only males and females; that the duty of the male is the defense of the nest against encroaching enemies, and that the duties of the females are to build the nest, lay eggs, and take charge of the young. Of course the males and females having different duties to perform will have their structures differently modified; say, in our case, the male has a largely developed head like the soldier-termite, the female a head like the worker-termite. Going a step further, neuters begin to appear, the aborted male still performing soldier duty, the aborted female still attending to its domestic duties. The neuters continuing to increase as we know they have increased, and the true males and females decreasing in number as we know they have decreased, a state of affairs is reached in which it is essential to the welfare of the colony that the male should confine himself to fertilizing the female, the female principally confine herself to laying eggs.

Thus far, the fertile and infertile males, the fertile and infertile females, have resembled each other; but disuse of parts induces retrograde metamorphosis, or modification or suppression of useless parts. If the males no longer use their heads and jaws to protect the com-

munity, these parts would decrease in size; if the females no longer assist in building, if their entire duty is to lay eggs, their wings, legs, jaws, etc., will decrease; the surplus of force thus entailed being added to the reproductive system. Thus, then, there would have been produced the four castes found among the termites; the soldier representing the typical male of the species, the workers the typical females minus the perfected reproductive organs. But—and here is the great difficulty—how can the changed male have given his lost organs to his sex, and the female have transmitted her original but now modified peculiarities to the workers; especially as neuters do not propagate, and hence can not transmit their characters to progeny? Another law solves a portion of the difficulty: peculiarities acquired at any period of life are apt to appear in the same sex at the same time of life. Disuse having wrought its changes on our fertile insects after they had reached their perfect form, we can not expect them to appear in offspring which never reach this form. The modifications of structure were produced that the reproductive system might be benefited; why, then, should they take place in those insects which have a rudimentary and hence useless reproductive system?

We have now to ask whether those larvæ which are to produce fertile insects resemble, in any stage of their existence, the larvæ which are to produce neuters; whether, for example, the fertile male termite resembles, at any time, the infertile soldier. The reply to this is partly positive, partly negative; the larva of the female termite resembles very nearly the larva of the worker; but there is no great resemblance between the male and the soldier larvæ; there is a greater resemblance between the pupæ.

The fact alone that the female of social bees, and the male and female of white ants, should be presented under two forms is no novelty in insect history. In the aphides or plant-lice a similar state of affairs obtains: there is the perfect and imperfect female. Even as high in the scale as butterflies dimorphism is not uncommon. Mr. Wallace has discovered two forms of the female of *Papilio Memnon*, an inhabitant of the East Indies, one of which has tailed wings, the other of which is tailless. Several butterflies have three kinds of females, or are trimorphic. Hence the mere differences between neuter and perfect insects are nothing unusual, considered as differences. Were the workers fertile and thus able to propagate their peculiarities, the difficulties would vanish; but the problem why a fertile female should give birth to two or three distinct forms is still shrouded by mysteries, accept what explanation we may.

Our alternative that the workers are the type from which the males and the females have diverged is only an hypothesis, but in view of the facts it is the only alternative left us; since the neuters themselves can not have diverged from any type on account of their sterility.

The conclusions, then, reached in this paper are, that in many cases the differences between fertile and infertile insects are due to the quality or quantity, or both, of the food given to the larvæ. This conclusion is of worth, since it is supported by Huber, Smith, Woodbury, and others; though these naturalists only apply it to the social bees. The suggestion of Professor Wyman, that the difference in development is due to the difference in the time the eggs are laid after fertilization, seems to be opposed to facts; especially to the experiment of Kleine, who reared worker-larvæ into queens by feeding them on royal food. The other conclusion is, that the neuters represent the type from which the true males and females have diverged; that in those cases where food is powerless, the neuter retains its immutability for the reason that its development is arrested at a certain stage; that is, it does not go beyond the state reached by the typical progenitor, while the perfect males and females go beyond this stage, and that the differences between them and the neuters were inaugurated at this time; that changed conditions have been potent in producing such differences; that the differences are only inherited at that advanced period of progression in which they were initiated. In other words, to render this conclusion plain to the general reader, we believe that if the neuter-worker of the white ant, for example, were to progress in development, it would turn into the fertile female; if the neuter soldier of the white ant were to continue on the line of development, it would become a fertile male. This does not give support to the theory that the worker and soldier are immature male and female; that they are the perpetual babies, while the perfect insects are adults—since we believe that in their way the neuters are as adult as their parents. This proposition may be rendered clearer by a symbol, which may be represented by the letter Y. The stem of this letter will stand for the typical insect represented at the present day by the neuter, and the two arms, respectively, will represent the male and the female, which, after the typical insect reached a stable form, diverged into new routes of progression.

At some future time we hope to work out this subject more elaborately, and, from the observations and facts already collected, it is believed that the theory can be defended if not vindicated. Our present purpose, however, has been accomplished—to introduce to the general reader a subject which has perplexed, and still perplexes, our greatest naturalists.

AGNOSTICISM AS DEVELOPED IN HUXLEY'S HUME.*

By JAMES McCOSH, LL. D.,
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PROFESSOR HUXLEY is a man of strong intellectual tastes and tendencies. He is evidently an enthusiast in his biological studies. It is not so generally known that he is also a metaphysician. This he has shown in his published address on Descartes and in other papers. He has now come forward to defend the study. (See "Popular Science Monthly," May, 1879.) Kant has made the remark that we can not do without metaphysics, and others have noticed that those who affect to discard them will commonly be found proceeding, without their being aware of it, upon a very wretched metaphysic. The Professor now tells us, "In truth, to attempt to nourish the human intellect upon a diet which contains no metaphysics is about as hopeful as that of certain Eastern sages to nourish their bodies without destroying life." He adds: "By way of escape from the metaphysical will-o'-the-wisps generated in the marshes of literature and theology, the serious student is sometimes bidden to betake himself to the solid ground of physical science. But the fish of immortal memory who threw himself out of the frying-pan into the fire was not more ill advised than the man who seeks sanctuary from philosophical persecution within the walls of the observatory or of the laboratory." He shows that such conceptions as "atoms," and "forces," and as "energy," "vacuum," and "plenum," all carry us, whether we will or no, beyond a physical to a metaphysical sphere.

I rather think that the Professor's metaphysics were derived primarily from David Hartley, but especially from James Mill, reckoned an age or two ago, in England, the chief philosophical authorities by those not trained at the two English universities. Hartley connected metaphysics with physiology; and James Mill, after abandoning the trade of a preacher, adopted the fundamental principles of David Hume, and transmitted them to his son John Stuart Mill, who modified and improved them by independent thought and a larger acquaintance with other systems. Professor Huxley has now, in this work on Hume, given his own philosophy, which is substantially that of Hume and James Mill, with some not very valuable suggestions from Bain, and a criticism now and then derived from Descartes and Kant, of whose profounder principles he has in the mean while no appreciation. It is expounded in the form of an epitome of the system of the Scottish scepter with constantly interspersed criticisms of his own. His style

* "Hume," by Professor Huxley.

is not that usually supposed to be philosophic : it is not calm or serene or dignified ; but it clearly expresses his meaning, and it is graphic, living, and leaping. He shows everywhere great acuteness, and the shrewdness of one who is not to be taken in by show and pretension, or awed by authority. No man is quicker in starting an objection, which, however, may be of a surface character, and not penetrating into the heart of the subject. I can not discover in his speculations the calmness of one who is waiting for light, or the comprehension of one who goes round the object examined and views it on all sides.

Mr. Darwin has elected and proclaimed Professor Huxley as the philosopher of his school, and this when many would place Herbert Spencer above him. I treat and criticise him as such. Most of the members of the school are not professed metaphysicians; but, like the man in the French play who spoke prose all his life without knowing it, there is a metaphysic underlying their reasonings ; and this metaphysic, without their being aware, is very much that of Mr. Huxley. I venture not to urge objections to his biology, of which he is a master, and to be reviewed only by a master in his department. But he is not so formidable as a metaphysician, and one with but a sling and stone may cast him down, and the philosophy of his admiring host, by a few facts as clearly revealed to our inner consciousness as the facts of physiology are to the external senses.

I am in this paper to develop first, one by one, the positions of Hume, then the modifications of these by Huxley. In proceeding, I will show how the negative positions of both are to be met. In the close, I will show what kind of knowledge agnosticism admits and what it denies, and estimate the influence it is likely to exercise upon the present age, and especially upon young men liable to be drawn into its vortex :

1. According to Hume, what is commonly called mind starts with *Impressions*. This is a very misleading term. Taken literally, it implies three things : a thing impressing, say a seal; a thing capable of receiving an impression, say wax; and a figure, say of a head, impressed. Applied, it ought to denote an external thing ready to impress itself, a mind to be impressed, and an impression, say a perception, made upon it. The language is unfortunate ; but, carrying out the similitude, we might have a psychology containing much truth : a thing perceived, a perceiving mind, and a perception. But according to Hume, followed by Huxley, we have none of these things. We have in our exercise of what are commonly called the senses no perception of anything, no mind to perceive, and no object to be perceived. We have simply a succession of passing states, and these states of nothing permanent.

This is the avowed doctrine of Hume. Huxley adopts it. He amends it by classifying the Impressions into—A. Sensations ; B. Pleasure and Pain ; and C. Relations. Let us confine our attention for the present to the first two, to Impressions, A. Of Sensation, and B.

Of Pleasure and Pain. Let us notice what we have got, as he describes it: "When a red light flashes across the field of vision, there arises in the mind an impression of sensation which we call red. It appears to me that this sensation red is something which may exist altogether independently of any other impression or idea as an individual existence. . . . The whole content of consciousness might be that impression." These Impressions, with the Pleasure and Pain, are represented by him as knowledge; this without a thing knowing or a thing known. It is such knowledge with which man starts, such knowledge as man can attain, and the foundation of all other knowledge.

He has already laid the foundation of agnostics. He has started with an assumed principle, from which only nescience can follow. These impressions can never by logic or any legitimate process give us the knowledge of things. The addition or multiplication of 0 can give us only 0; so the additions or multiplications of impressions, of sensations, of pleasures and pains, can give us only impressions in sensations and in pleasures and pains.

Now, all this is to be met by showing that the mind begins in sense-perception with the knowledge of things. It knows this stone as an existing and resisting object. It knows self as perceiving this object. "The whole content of consciousness" never is a mere impression, say a sensation of red. It is of a thing impressed. If I am asked for my proof, I answer that all this is contained in my very consciousness. I have, in fact, the same evidence of this as I have of the existence of the impression "red." I am conscious of self perceiving a red object. Indeed, any impression I may have is an abstraction taken from the self impressed.

2. Omitting for the present the impressions of Relation, we now view the only other content which he gives the mind, IDEAS, which he defines "copies or reproductions in memory of the foregoing." We are here at the point at which Mr. J. S. Mill was so perplexed. He saw, and acknowledged in his candor, that in memory there is more than a mere copy or a reproduction. There is *the belief that the event remembered has been before us in time past.* We thus get the idea of time always in the concrete; that is, an event in time, and by abstraction we can separate the time from the events in time. We have got more. We intuitively believe that we are the same persons at this present time as we were when days or years ago we witnessed the event. We can not be made to believe otherwise. In this process we are adding knowledge to knowledge, and this a knowledge of ourselves and of other things. These are all revealed to and attested by consciousness, the organ of things internal. The person who would overlook such important facts as these in the animal structure would be terribly lacerated by our acute zoölogist.

3. The next step in the progress of the mind is the discovery of Relations. Hume's account of the relations which the mind can dis-

cover is taken from Locke and improved, and is very large and comprehensive. He makes them to be eight in number: Resemblance, identity, space and time, quantity, quality, contrariety, cause and effect. He exerts all his ingenuity, I believe fruitlessly, to show that these can not extend our knowledge beyond impressions and ideas, which are mere reproduction of impressions. They are relations of impressions and ideas, and not of things. We meet this skepticism on the part of Hume and agnosticism on the part of Huxley by maintaining that what we perceive originally are things, and what we perceive by the faculty that discovers relations are relations of things. When we classify plants by their resemblances, we classify the plants and not impressions. When we decide that a thing which begins to be must have a cause, we have a reality: first, in the thing that begins to be; which implies, secondly, a reality in the cause which we regard as producing it. It is thus that we argue that the present configuration of the earth, being an objective reality, is the result of agencies which acted thousands or millions of years ago. It is thus we argue that the adaptations we see in the eye must have had a cause in an adapting, that is, a designing power. Professor Huxley's account of the relations which the mind can discover is much more meager than that of Hume. Apparently, following Professor Bain, he makes them consist in coexistence, succession, and similarity. He thus gets rid dexterously of the relations of quantity on which mathematics, with all their certainty, so obnoxious to the skeptic, depends; and of identity, which certifies to the soul's continued and permanent existence; and of causation, which leads us from harmonies and adaptations, from order and design in nature, to rise to a producing power in a designing Mind. The three which he acknowledges—similarity, coexistence, and succession—are all regarded as relations among impressions and ideas, and tell us nothing as to realities.

This is the intellectual furniture of the mind, according to Huxley. Observe what it is: Impressions, Ideas, and Relations among these. He calls these the "Contents of the Mind." It is the most miserably defective account of the mental powers I have met with anywhere; more so than that given even by Condillac and the sensational school of France, who gave to the mind a power of transforming its sensations into a considerable number and variety of elevated ideas.

4. Having thus allotted to the mind so small a content, he finds it the more easy to refer the whole to cerebral and nervous action. "The upshot of all this is, that the collection of perceptions which constitutes the mind is really a system of effects, the causes of which are to be sought in antecedent changes of the matter of the brain, just as 'the collection of motions' which we call flying is a system of effects, the causes of which are to be sought in the modes of motion of the muscles of the wings. . . . What we call the operations of the mind are functions of the brain, and the materials of consciousness are products

of cerebral activity." The Professor here defends a doctrine from which I rather think Hume would have turned away. With all his skepticism, Hume was fond of dwelling on mental rather than on material operations. Such sentences show that Huxley may be properly called a materialist. He denies, indeed, that he is a materialist. The fact is, that he is an agnostic, believing in neither mind nor matter as substances. But then he makes all agency material. "The roots of psychology lie in the physiology of the nervous system." He gives a physical basis to all mental action—inconsistently, I think, for I can not find that on his principles he is entitled to seek for any basis. Neither reason nor experience sanctions the doctrine that matter can produce mind; that molecules or masses of matter can think or feel, or discover the distinction between good and evil. At this point Huxley seems to separate from such men as Tyndall and Du Bois-Reymond, who tell us that to bridge the wide gulf that divides mind from matter is altogether beyond human capacity or conception.

5. At this point it will be necessary to refer—I can do so only briefly—to the question so important in philosophy, as to whether the mind discovers some objects and truths at once, and without a process—that is, by intuition. Hamilton, in his famous Note A, appended to his edition of Reid's "Collected Works," has shown that all thinkers, including even skeptics, have been obliged to assume something without proof, and to justify themselves in doing so. In my "Examination of Mr. J. S. Mill's Philosophy" I have shown that, in his "Examination of Hamilton's Philosophy," he has assumed between twenty and thirty such principles. With Locke I hold that the primary mark of these intuitions is self-evidence. We perceive things and truths by simply looking at them. Intuitions are not high *a priori* truths independent of things, but they are involved in the very nature of things, and we perceive this as we look at them. Thus we know, by simply looking at them, that things exist; that if two straight lines placed alongside proceed an inch without coming nearer each other, they will not approach nearer, though prolonged through all space; that two things plus two things make four. Truths thus self-evident to our minds become necessary; we can not be made to judge or decide that they are not true. Necessity is commonly put forward by metaphysicians such as Leibnitz and Kant as the test of such truths. I regard it as the secondary, the primary being self-evidence.

Hume and Huxley have discussed the question of Necessity especially as applied to causation. Hume accounts for it by custom and association of ideas: we are accustomed to see cause and effect together, and when we see the one we are constrained, whether we will or not, to think of and expect the other. But this is not the kind of necessity which metaphysicians appeal to. Necessity as a test of truth is a necessity of cognition, belief, or judgment, arising from our viewing the nature of the object, as, for example, when on contemplating

two straight lines, we perceive, without any mediate proof, that they can not inclose a space. Our commentator on Hume has equally misunderstood the nature of this necessity. He speaks of three kinds of necessity. The first is one merely requiring the consistent use of language: "The necessary truth A = A means that the perception which is called A shall always be called A." This throws no light on our convictions. The second, "The necessary truth that 'two straight lines can not inclose a space,' means that we have no memory, and can form no expectation of their so doing." The instance he gives is a good example of an intuitive truth seen at once, and necessarily believed; but it surely implies vastly more than merely that we have no memory, and can form no expectation of two straight lines inclosing a space; it means that we perceive that, from the very nature of things, two such lines can not inclose a space. He has a third case of necessity, "The denial of the necessary truth that the thought now in my mind exists, involves the denial of consciousness." This is also an example of a self-evident, necessary truth, but it is so because we have an immediate knowledge of ourselves as existing.

6. Hume's doctrine of causation takes a double form; the one objective, the other subjective. These two are intimately connected, and yet they should be carefully separated. Hume held that objective causation is only invariable antecedence and consequence. This is a doctrine contradicted both by metaphysical and physical science. It seems very clear to me that our intuitions, looking on objects, declare that they have power. This is implied in the axiom that we know objects as having properties; and what are properties but powers? Then modern science has established the doctrine of the conservation of energy; namely, that the sum of energy, actual and potential, in the world is always one and the same. Causes are not causes simply because they are antecedents; they are antecedent of the effects because they have power to produce them.

It would be preposterous in so short a paper as this to dive into all the subtilties of the subjective question as to whether our belief in causation is intuitive, or is derived from a gathered experience. The settlement of this question will depend on the way we settle the one started under the last head, as to whether there are not truths which shine in their own light. If there be such truths, then causation is undoubtedly one of them. When we see a thing produced, a new thing, or a change in an old thing, we look for a producing cause having power in its very nature, and ready to produce the same effect in the same circumstances.

7. By his doctrine, defective as I reckon it, Hume undermined the argument for the Divine existence. There is evidence in his life, in his correspondence, and in his philosophic writings, that, like John Stuart Mill, in a later age, he looked with a feeling of favor upon the seeming evidence for the existence of a designing Mind in the uni-

verse. But neither of these men could find a conclusive argument. Huxley follows them here. The three are to be met in the same way. The philosophy of all of them is erroneous. Man has the capacity to discover that, by the very nature of things, everything that begins to be must have a cause. If a world begins to be, if there be a fitting of things to one another in the world, then there must be an adequate cause in a power and purpose on the part of an intelligent Being. Our agnostics can answer this only by making man incapable of knowing anything of the nature of things.

8. According to the philosophy of Hume, there is and can be no evidence of the immortality of the soul. If mind be the product of matter, specially of the collection of nerves, then, on the dissolution of the body generally, and especially of the brain, there is no proof that the soul survives; indeed, there remain no means, in fact no possibility, of its action. The moral argument so powerfully urged by Kant in favor of a judgment-day and a life to come to satisfy the full demand of the law, is entirely undermined in a philosophy which does not admit of an authoritative and imperative morality, and does not call in a God to make the moral law work out its effects. This skepticism is to be met by showing that mind and matter are made known to us by different organs, the one by the self-consciousness, and the other by the senses; and that they are known as possessing essentially different properties, the one as thinking and feeling, and the other as extended and resisting our energy. That the body dies, is no proof that the soul must also die. If these truths be established, it is seen that the usual arguments for another life retain their force. Believing in God, and in his law, we are convinced that he will call all men to judgment.

9. But it may be urged that, though the philosophic or scientific arguments in behalf of religion fail us, we may resort to revelation. But both Hume and Huxley deprive us of this refuge. Hume does not, like certain bewildered German speculators, deny the possibility of a miracle. His position is, that there is no evidence to support any given miracle. He defines miracles as "a violation of the laws of nature," and labors to show that the testimony in behalf of a miracle is more likely to be false than that the order of nature should be violated. Huxley objects to his definition of a miracle, as many had done before. But he urges the same objection in a somewhat different form: "The more a statement of fact conflicts with previous experiences, the more complete must be the evidence to justify us in believing it" (p. 133). He decides that there is no such evidence as is fitted to sustain an occurrence so contrary to our experience as a miracle. Huxley advances nothing new on this subject, and the defenders of Christianity maintain that they can meet the objections he adopts. They show, first, that they can produce testimony in favor of certain miracles, such as the resurrection of Jesus from the dead, more full and explicit,

than can be advanced in behalf of the assassination of Julius Cæsar, or the best-authenticated occurrences in ancient times. They show, secondly, that there is an accumulation and a combination of evidence in favor of the life and mission of Jesus Christ: in the prophecies uttered ages before; in the results that followed the propagation of the gospel; and, above all, in the fitness of Christ's work to remedy the acknowledged evils in the world, and in its adaptation to the felt wants, moral and spiritual, of man. It might be shown that the cumulated evidence in behalf of the Christian revelation is not unlike that brought to prove the uniformity of nature.

10. Professor Huxley has nothing original to advance on the subject of moral good. Neither of them holds the selfish theory of morals. Both hold that man has a native instinct which leads him to sympathize with his neighbor, and to be pleased at seeing him happy. So far both are right; but, on the very same ground on which it is shown that there is a disposition in our nature to promote the pleasure of others, it can be shown that there is a principle in our nature which leads us to approve of what is good and condemn what is evil.

We are now in a position to discover and comprehend what agnosticism is, as expounded by its eminent living philosopher. Notwithstanding the meaning of the term, it is claimed by the whole school that there is knowledge gradually accumulating. According to our professor there are sensations, there are pleasures and pains, and among these are relations of coexistence, of succession, and similarity. By observing these we may form science, which is systematized knowledge. He who is master of the sciences is a learned man, and may be very proud or vain of his acquirements. Professor Huxley, as being acquainted with a number of the sciences, is undoubtedly possessed of much knowledge.

What, then, it may be asked, is defective or fault-worthy in the philosophy of agnostics? Its error lies in its avowed fundamental principle that we know only impressions, or, as Kant expresses it, appearances, and do not know things either mental or material. All that we know are impressions—impressions recalled and impressions correlated. The correlations constitute the various sciences.

There are *savants* who have a large acquaintance with these impressions and their correlations. But all the while they know nothing and never can know, or come nearer knowing, the things thus appearing and thus correlated as appearances—if, indeed, there are any things. It is not positively asserted that there are things, but it is certain, according to Kant, followed by Spencer, that there are, unknown and unknowable by man with his present faculties. It is curious to find the metaphysical Hume and the physical Huxley at one on this point.

In one sense Huxley is entitled to deny that he is a materialist. He believes as little in the existence of matter as he does of mind.

But he does claim that the impressions which we call mental are produced by those we call material, namely, cerebral action. So far he is a materialist, and the undoubted tendency of his philosophy is materialistic—he makes matter the basis even of mental action. He is not like Hume a skeptic, for he does not affirm that there are no things: all that he says is, that if they exist we can not know them; or, rather, that things known to us are merely impressions in the shape of sensations—of sensations remembered and correlated. He is not an atheist, not he; he only says that we have no proof of the existence of God. He is simply an honest agnostic—not believing in mind, or in matter, or in God. What is the tendency of such a system?

1. It makes us feel that we are in a world of illusions. I say illusions, and not deceptions; for, as Nature does not profess or promise anything, it can not be charged with intentional deception. But then we may be deceiving ourselves or deceiving others; and agnostics show that we are doing so. I maintain that it strips us of many of our natural beliefs—beliefs which men have entertained in all ages and countries. The great body of mankind believe that they themselves, and the objects they have to deal with, are more than impressions, and that they are realities in a real world; that there is matter that is solid, that there is mind that thinks and feels, that we all possess a soul, and that our neighbors also have souls. I am prepared to show that these convictions are valid; that we have the same evidence of a self thinking, and of body resisting our activity, as we have of the existence of impressions. But suppose these convictions removed, and how do we feel, and what have we left us?

Will we be apt to set a higher value on life when we know it to be a mere bundle of impressions with unsubstantial ideas growing out of them? Will we take a deeper interest in our neighbors when we have come to believe (theoretically, for to believe this practically is impossible) that they too are a mere congeries of appearances? Will we be disposed to do more for the world when we regard it as a set and series of phantasmagoria bound by rigid uniformities of likeness, coexistence, and succession? Will we be more likely to feel that life is worth living for, and that it is our duty to work for its good, when we contemplate it as in fact a mere series of images which do not reflect any reality? Will not one hindrance to self-indulgence be removed when we are made to acknowledge that sensations and pleasures are realities, and that there are no others? Will not one hindrance to self-murder, which we may be tempted to commit when in trouble, be removed when we are sure that we are merely stopping a series of sensations? Will the regret of the learned murderer be deepened when he is told that he has merely laid an arrest on a few pulsations? Will the seducer be more likely to be kept from gratifying his lust when the highest philosophy teaches him that the soul of his victim is a mere collection of nerves? Is the youth who has run in debt less like-

ly to rob his master when he is assured that both he and his master are mere throbs in the vibrations which constitute life? Agnosticism never can become the creed of the great body of any people; but should it be taught by the science and philosophy of the day, I fear its influence on the youths who might be led, not to amuse themselves with it, but by faith to receive it, would be that they would find some of the hindrances to vice removed, and perhaps some of the incentives to evil encouraged.

2. Thus far as to the influence of the philosophy on common morality. It is allowed that the system undermines all belief in the supernatural. All who know anything of it know this. But some do not realize it. The creed destroys the foundation of all religions, even the rationalistic, not only supernatural but natural theism, not only Christianity but every form of deism. Last century Franklin could say: "Here is my creed: I believe in one God the Creator of the universe; that he governs it by his providence; that he ought to be worshiped; that the most acceptable service we render him is doing good to his other children; that the soul of man is immortal, and will be treated with justice in another world respecting its conduct in this. These I take to be the fundamental points in all sound doctrine" (from letter by Hon. J. Bigelow in "New York Observer," July 3, 1879). But the superstition which clung to Franklin in the eighteenth century is all dissipated by the philosophy of this century.

Shrewd men have long seen and often said that, if Christianity be set aside, deism will soon follow. We see this already realized. Agnostics feel an avowed pleasure in pointing out the positive contradictions involved in every form of natural religion. All who adopt the system should know that they must be prepared to part with all the consolation that can be derived from religion, natural or revealed, and from all the restraints which it lays on evil conduct. Some may be rejoicing in agnosticism because it relieves them from all ghostly terrors; but it does not therefore follow that their happiness will be increased. I am aware that speculative beliefs do not always lead to corresponding practice; but their tendency is to do so, and when they do not it is because they are counteracted by opposing principles good or evil. I am sure that agnosticism, when it has time to work, will be followed by important consequences. I am not to be charged with the fallacy of arguing that, because a system is charged with bad results, it must therefore be false. I am showing that the system is false, and thus leads to prejudicial consequences—false to our nature, false to the ends of our being.

THE AGE OF CAVE-DWELLERS IN AMERICA.

By E. T. ELLIOTT.

THE various writers and thinkers on the subject of pre-historic man generally concede that the races of to-day have radiated over the globe from some point in Asia. Indeed, the traditions of different nations lead to the conclusion that this point of dispersion was located in the high central regions of that country. There, apparently, the dog, horse, and ox were first domesticated, and can at the present time be found in their natural, wild state. Hudson Tuttle says, in his "Arcana of Nature," that "man originated near the equator, where the climate was better adapted to his defenseless condition and food abundant."

This conclusion seems to be based upon the impression that the different zones of the earth occupy the same relative positions now that they have always done, and can hardly hold good in view of recent developments. Colorado, an almost unexplored country, comparatively speaking, to the scientific world will be apt to change the logical reasonings that have so far been advanced upon this interesting subject.

Señor Altamirano, of Mexico, the best Aztec scholar living, claims the proof is conclusive that the Aztecs did not come to Mexico from Asia, as has been long universally believed, but that they were a race originated in the unsubmerged parts of America, as old as the Asiatics themselves, and that *that* country may even have been peopled from this. From the ruins recently found, the most northern of any yet discovered, the indications of improved architecture, the work of different ages, can be traced in a continual chain to Mexico, where they culminate in massive and imposing structures, thus giving some proof by circumstantial evidence to Altamirano's reasoning. But now, as to the antiquity of American man as shown by the yet recent discoveries in Colorado.

First it will be necessary to glance at the glacial period for an instant, or rather at the geological spring following it, when the warm rays of the sun turned the ice-covered crust of earth into a vast sheet of water, with only the extremely high ground left exposed above its surface.

From the evidences of the rocks and the deposits of the mountain valleys it is fair to deduce the conclusion that, as in time the waters gradually receded, the first part of America to assume any dimensions was the backbone of the continent, or that elevated portion known as the Rocky Mountains, which had probably never at this period been entirely covered with water, thus affording a long, continuous stretch of dry ground on which man and beast could live and wander as they listed.

At this period, it has been stated by many and believed by most, that the present line of the equator was where man originated and flourished, because of the warmth of the climate and abundance of easily procurable food. Yet the evidences in Colorado are opposed to this belief, for *here* were the tropics also.

The existing specimens of perfectly-preserved petrified palm-trees show this, so also do the petrified remains of gigantic turtles peculiar to tropical waters alone. The Asia theorists also offer the nativity of the horse as a strong argument in their behalf, claiming that man and horse developed at about the same time. If this claim has any weight, it more than settles the point in favor of America, for the fossil remains of horses with three toes to each foot have been found in Colorado, and the examination of any hoof of a horse in embryo will show this to have been one of the earliest stages in the existence of that animal. This evidence goes beyond the researches of the supporters of the Asia theory, for their conclusions are based upon the fact of the existence of the wild horse of the present time.

These evidences of tropical life in Colorado, it must be remembered, are found at an altitude of ten thousand feet, or near the present snow line. As the waters gradually receded, they left the valleys and parks throughout the mountains immense lakes, until a trickling and overflowing outlet wore its way into a deep cañon through solid granite, and liberated the pent-up waters of each.

The San Luis Valley, in which Del Norte is situated, is in the southwestern part of Colorado, and is from sixty to seventy miles broad by about three hundred miles long, and the outlet for drainage is now the beautiful snow-born Rio Grande.

Hearing one day in December, 1877, that a gentleman acquaintance, in wandering over the foot-hills, about three and a half miles from Del Norte, had found a small arrow-head of chalcedony, it aroused my curiosity, and I at once called upon him that I might see it. He showed me a beautiful specimen of elegant workmanship, made with great care and accuracy as to dimensions, but evidently intended for an ornament, being too small and delicate for any other actual use.

The present Indians never work in chalcedony, and I felt sure some discoveries might be made by visiting the spot; so, calling together a couple of friends, we mounted our horses and had a delightful canter over the floor-like valley until we reached the base of the hill on top of which the specimen had been found. We dismounted, tied our horses, and began climbing up and up for several hundred feet above the valley, pausing now and then to breathe and enjoy the magnificent view extended at our feet—the valley stretching away like an ocean of molten gold, with its autumn-tinted grasses, a hundred miles to the north and seventy miles to the east, where it came to an abrupt ending against the solid bases of the majestic peaks comprising the Sangre-del-Christo range of mountains. No foot-hills inter-

vened to obstruct the view; the clear-cut and sharply defined peaks stand in an unbroken file, an army of Nature's monarchs, clad in Nature's livery, a uniform of perpetual green, and crowned with helmets of eternal snow.

We finally reached the summit—our objective point—and began winding our way around huge obelisks of sandstone, and through a perfect net-work of passages and crypt-like fissures. We felt as though we had entered the Cretan labyrinth, but, not so fortunate as Theseus, had no thread to guide us, until we came upon the first ancient habitation.

Climbing through a narrow crevice with some exertion, we observed a cave-like opening in the rock fronting us, and of course were but an instant in gaining an entrance, where we were delighted to find, upon examination, the evident handiwork of man.

Here was an apartment about six by eight feet in size, where nature had formed two sides and the sloping roof. One side had been left open, and the other, from the yet remaining fragments, showed plain evidences of having been roughly walled up with loose stones. A fissure in one corner of the room, leading out through the roof, showed traces of discoloration by fire, and digging down with some sticks through the rubbish, we found that corner had been used as a fireplace, and at a depth of eighteen inches we still found the wall with strong evidences of the action of heat on the stones, finally unearthing some charcoal, and from a repository in the wall about a half peck of chips of chalcedony: judging from this latter *find* that we were in the workshop of the former inhabitants of the place.

We were not prepared for excavating through the dust of ages which Time had caused to settle on the floor, so started out eager to find other places of habitation. Our search was rewarded by finding during the afternoon some twelve or fifteen more houses or caves, many of them, however, especially those along the face of the cliffs, having nearly disappeared from the effects of the disintegration of the rocks.

We found no more dwellings as large as the workshop, the majority of them being very small, the rough traces of walls nearly always visible, but the caves so circumscribed in extent it seemed impossible that human beings could have lived in them. Yet each one had its fireplace plainly to be seen, and each one had certainly been at some time a dwelling or shelter from the elements.

Continuing our search, we also found two furnaces—primitive, 'tis true, but none the less furnaces—showing the effects of great heat, and a deposit of dirt-covered ashes several feet in depth. These furnaces were hollowed out of immense bolwders by man or nature—we could not decide which, owing to the action of the fire—and the interior of each almost exactly resembled the interior of a Dutch oven, having in like manner a small orifice for draught.

They appeared to be mostly the work of nature adopted with but little change, if any, by man for his own uses. However, on this point the different members of the party failed to agree.

What this race cooked, baked, or burned in them yet remains to be seen. From the quantity of the deposit, and as no human remains have been found, nor any semblance of graves, it may be that their method of disposing of the dead was by cremation.

Now, who and what were these people? The modern Indians know nothing of them, never inhabit caves, and say that none of their traditions show that their ancestors ever lived in them.

They could not have been a race of giants, for the caves inhabited by them were too small for their accommodation. Yet here was a colony living at an altitude of eight thousand feet above the level of the present sea, the nearest water at this time being the river two and a half miles away, and to reach it an abrupt descent must be made of several hundred feet. Appearances and surroundings indicate that these caves were inhabited during the period when the San Luis Valley was an immense lake or sea; and when *that* valley was a *lake* where was the rest of America? The valley is seven thousand feet above the ocean, and a natural inference would prompt one to conclude that most of the continent was under water.

I will here state that though interested in the subject, I am not enough versed in it to venture my opinions before those who have made it a life-long study, but would ask, If the cave-dwellers were among the earliest developments of man, and these Colorado men were cave-dwellers at the period of general moisture, with a tropical climate preceding them, is it reasonable to suppose that they could reach this point from Asia?

It is easy to follow these people from their traces as they improved in knowledge with time. They passed southward, apparently following the warm climate, stopping for ages at a time in some *now* sterile valley, which when occupied by them must have been rich and fertile; their gradually improving architecture extending down the La Plata, Mancos, San Juan, and Colorado Rivers, through Arizona, and, as I before said, culminating in the comparatively modern buildings of the highly intelligent Aztecs.

CHLORAL AND OTHER NARCOTICS.

By Dr. BENJAMIN W. RICHARDSON, F. R. S.

I.

IT fell to my lot to be the first in this country to investigate the action of hydrate of chloral after the remarkable discovery of its properties as a narcotic by the distinguished and original Liebreich. At the meeting of the British Association, held at Exeter in the year

1868, the late Mr. Daniel Hanbury, F. R. S., brought with him to the meeting, from Germany, a specimen of the hydrate and a brief verbal account of the phenomena which it had been found to produce on living bodies. The facts related by Mr. Hanbury proved of so much interest to the members of the Biological Section, that they elected me, who had just been submitting a report on an allied subject, to make a further and special report during the meeting on this particular subject. I accepted the duty at once, and conducted a series of experimental researches, the results of which were duly laid before the section on the last day of the meeting. The results were among the most singular I had ever witnessed, and the report upon them raised an intense curiosity among the medical men and the men of science in this country. Liebreich's discovery became the physiological event of the year, and for some months I was engaged, at every leisure moment, in demonstrating the various and unique facts which that discovery had brought forth.

In this chloral hydrate we were found to possess an agent very soluble and manageable, which, introduced into the body of a man or other animal, quickly caused the deepest possible sleep, a sleep prolonged for many hours, and which could be brought so near to the sleep of death that an animal in it might pass for dead and still recover. In this substance we also found we had an agent which was actually decomposed within the blood, and which in its decomposition yielded the product chloroform which caused the sleep; a product which distilled over, as it were, from the blood into the nervous structure, and gave rise to the deep narcotism.

The discovery of Liebreich opened a new world of research, the lessons derived from which I shall never forget. And yet, now that ten years have passed away, and I have lived to see the influence on mankind of what is in one sense a beneficent, and in another sense a maleficent substance, I almost feel a regret that I took any part whatever in the introduction of the agent into the practice of healing and the art of medicine.

About three months after my report was read at the meeting of the British Association for the Advancement of Science the first painful experience resulting from chloral hydrate came under my knowledge. A medical man of middle age and comfortable circumstances took, either by accident or intention, what was computed to be a dose of 190 grains of chloral hydrate. He had bought, a few days before this event, 240 grains of the substance. He took a first dose of ten grains in order to procure sleep. On a following night he took twenty grains, and on the evening of the succeeding day twenty grains more. These administrations were known. He had reduced his store by these takings to 190 grains, and, while in a state of semi-consciousness from the last quantity, he got up from the bed on which he was reclining, and emptied all the remaining contents of the bottle into a small tum-

bler of water, and swallowed the large dose so prepared. He was found insensible, with the bottle and glass by his bedside. He did not fully regain consciousness for sixty hours, but finally made a good recovery.

The occurrence of this experience led me into a new line of research, namely, to find out what was the best mode of maintaining life while the body is under the influence of a deep sleep from the hydrate. This new research disclosed that the great object of treatment should be to sustain the animal temperature. I found that, like alcohol, the tendency of chloral hydrate is to reduce the vital fire, and that of two animals under chloral, one in a warm, the other in a cold atmosphere, the recovery of the one in the warm and the death of the one in the cold atmosphere could be reduced to a matter of positive system or rule. I had soon to publish that lesson, and to indicate that there were dangers ahead in respect to the use of chloral hydrate, which dangers would have to be scientifically combated.

Within a year after the introduction of chloral hydrate into medical use another new truth dawned on me. One morning the friends of a gentleman called on me, bringing a bottle of chloral hydrate and a copy of a medical paper containing a lecture of mine relating to the action of the drug. They had noticed for some time past that the gentleman, about whom they were anxious, had been very peculiar in manner, exhibiting signs resembling those of intoxication from alcohol, but with more than alcoholic somnolency. He was an alcoholic, and sometimes he was apt to have spells of inebriation ; but the phenomena more recently observed were somewhat different. Watching him closely as their alarms increased, they detected that he was in the habit of dosing himself with some substance which he kept in a series of bottles, of which he had seventeen or eighteen in stock, and one of which they brought to me. The bottle they brought contained chloral hydrate, and it turned out that all the bottles contained, or had contained, the same. By and by this gentleman came to me himself, and confessed that he was in the habit of taking the chloral three or four times in the twenty-four hours. He took it at first, after reading my lecture on its medicinal uses, in order to procure sleep. It answered his purpose so well that he became induced to repeat the process, and in a little time got what he called his new craving. He presented a series of special symptoms from the chloral which had some of the characters of jaundice and some of the characters of scurvy. These symptoms were additional to the signs of brain and nervous disturbance caused by the chloroform derived from the chloral, and they were easily accounted for. The chloral, in undergoing decomposition within the body, divides into two products, the one chloroform, the other an alkaline formate, a soluble salt, which makes the blood unduly fluid, and acts much in the same manner—as I found again by direct experiment with it—that common salt does, or the mixture of pickling

salts used for the preservation of dead animal tissues that are preserved by the process of salting.

Here, then, was another history of danger from the use of chloral hydrate, a new condition of disease to which I drew attention very speedily, and to which I gave the name of *chloralism*. It is a matter of deep regret to have to report that since the name was given to the disease chloralism has become rather wide-spread. It has not yet spread far among the female part of the community. It has not yet reached the poorer classes of either sex. Among the men of the middle class; among the most active of these in all its divisions—commercial, literary, legal, medical, philosophical, artistic, clerical—chloralism varying in intensity of evil has appeared. In every one of the classes I have named, and in some others, I have seen the sufferers from it, and have heard their testimony in relation to its effects on their organizations—effects exceedingly uniform, and, as a rule, exceedingly baneful.

The history of chloralism is of interest to the scholar of history as showing how easily a simple scientific discovery may be misapplied when its misapplication ministers to some luxurious desire or morbid inclination of mankind. I give the account at first hand, drawing upon no other experience than my own, an experience which dates from the first commencement of the disease, and which, during all the period, has been probably, in this country, as comprehensive as any in respect both to instances of acute and of slow mischief from this one cause. I could fill easily all the space allotted to me in the present essay by mere narration of observed facts on this topic, were that my object. My object does not lie in that direction, useful and practical though it might be. Let the reader simply remember that from a certain scientific basis of research something specifically social, and either moral or immoral in its tendencies, has occurred in a brief space of time, and that a singular mental phenomenon has been developed among the most cultivated representatives of a highly cultivated people, and the impression I wish now to indicate by the brief narrative recorded above is supplied.

This is not the first time in the history of mankind that the same kind of history has been written. There is a previous history, from which dates a great deal that is curious in romance and poetry, and which even to Shakespeare afforded a world of wonder and of story.

The ancient physicians, dating from Dioscorides himself, tell of the use of a wine made into a narcotic by mandragora. From the leaves and from the root of the *Atropa mandragora* the ancient physicians prepared a vinous solution which in many respects had the same properties as the chloral hydrate of to-day. This wine, called "morion," was given to those who were about to be subjected to painful surgical operations or to the cautery, so that, ere the sensitive structure was

touched, the sick man was in a deep sleep during which the operation was performed without the consciousness of feeling, not to say of pain. The sleep would last for some hours. From this purely medical or surgical use of morion, the application of it extended. Those who were condemned to die by cruel and prolonged torture were permitted to taste its beneficence and to pass from their consummate agony through Lethe's walk to death. A little later and the wine of mandragora was sought after for other and less commendable purposes. There were those who drank of it for taste or pleasure; and who were spoken of as "mandragorites," as we might speak of alcoholics or chloralists. They passed into the land of sleep and dream, and waking up in scare and alarm were the screaming mandrakes of an ancient civilization.

I have myself made the "morion" of that civilization, have dispensed the prescription of Dioscorides and Pliny. The same chemist, Mr. Hanbury, who first put chloral into my hands for experiment, also procured for me the root of the true mandragora. From that root I made the morion, tested it on myself, tried its effects, and re-proved, after a lapse of perhaps four or five centuries, that it had all the properties originally ascribed to it. That it should have come into use as a narcotic by those who first tasted it for its narcotic action, and that they should have passed into mandragorites, is not more surprising than that other and later members of the human family should have become chloralists. The effects produced by morion subjectively and objectively are so much like those from chloral that they may be counted practically as the same. I have put these two examples of the action of two similar toxic agents in parallel positions, because they are remarkable as showing how, at most distant and distinct eras of civilization, a general practice in the use of these agents sprang out of a special practice relating to their use, a maleficent out of a beneficent purpose. If I wished to extend the comparison, I might place opium, ether, chloroform, and chlorodyne under the same category.

Mandragora, opium, chloral, ether, chloroform, chlorodyne, are medical agents used in the first instance mechanically, and used in a second instance socially, and by habit in certain instances, for the purpose of making the mind oblivious, or, in other and more frequently used words, for securing repose or rest. These agents do not stand alone in respect to the list of toxicants which are assumed to be useful to mankind. To them must be added many others which have not necessarily had an origin from medical science or art, but have sprung into general use from their first application. Under this head may be included the commoner members of the chemical families known as the alcohols: hasheesh from the *Canabis indica* (Indian hemp), yerba de nuaca, or red-thorn apple, almanitine, coca, absinthe, arsenic, tobacco.

It will be seen that the toxical agents are a numerous class, and, if I had chosen to refine, I might have added some further. In one

notable instance, and in one or two less notable, nitrous-oxide gas, the gas now so commonly used by dentists as an anæsthetic, has been resorted to as an habitual stimulant and narcotic; but the rarity of its use prevents the necessity of doing more than referring to it in this place, and once perhaps again in the sequel. Of the other agents it may be said, *in limine*, respecting the extent of their use, that the alcohols and tobacco stand first on the list in our civilized life. Next after these come opium, absinthe, chloral hydrate, chlorodyne, ether, and chloroform. The other substances are local in the range of their employment. Hasheesh is an Eastern luxury; amanitine a Kamtchatkan luxury; arsenic a Styrian luxury; red-thorn apple a luxury of the Indians of the Andes, under the sweet influence of which they enter into communion, as they believe, with the spirits of their departed dead—the best excuse I have ever heard given for the use of any of these indulgences whatsoever.

As we cast our minds back upon this long list of toxical instruments for the delight of man, we are struck with the widely apparent difference that seems to exist between them. The difference, however, is not so great as it may seem, for between the physiological action of one and the other there is an analogy of action in certain particulars which is singularly striking. As a rule, the key-note of the action of these agents, if I may use such a simile, is through one particular element where many elements enter into their composition. Where nitrogen is present as an element, a definite line of action of the agent is marked out; when a hydrocarbon radical is dominant—that is to say, when such a radical forms the chief part of the compound—the influence of that is most definite; while the influence of one disturbing principle on another may be most clearly traced in other cases as a neutralizing influence, one influence reacting upon the other.

We have at hand many instances of this kind for illustration. Alcohol and tobacco are the most ready examples. In the alcohols, whichever one of the family of alcohols we may take, from the least dangerous wood-spirit, through the more dangerous grain-spirit, up to the much more dangerous potato-spirit, there is one agency at work, a hydrocarbon radical, methyl, ethyl, amyl, according to the alcohol used, which, with different degrees of intensity, plays the same part, producing similar series of phenomena. In tobacco we have a less decisively known combination at work, but we have in that combination the element nitrogen, the introduction of which causes a new development of nervous phenomena, the analogous action of which can be traced through some other complex organic compounds containing the same element—nitrogen. In chloroform, again, we have a hydrocarbon radical playing nearly the same part as the radical methyl of methylic alcohol, but with chlorine interposing to modify the simple narcotic action of the radical, and greatly to increase the danger of

the compound in its effect on the living body. Physiological research has not yet reached, by vital analysis of action, a perfection of knowledge on the subject now in hand. Such analysis is yet in its early days. At the same time a general line of research has been made out, and some results have been obtained which are of direct practical value. Other facts have also been elicited which at first sight are surprising, but which lose their singularity when they are correlated with pure chemical physical demonstrations. I found, for example, in one of my researches, that two chemical substances which are isomeric in constitution—that is to say, are composed of the same elementary forms in the same proportions, but under different arrangement—produce entirely different phenomena on the animal body. These isomeric substances are the formiate of ethyl and the acetate of methyl.

The agents used by man for his dreamy delights have thus a varied influence on his nature. They are often rudely classed together as luxuries ; but the luxuriousness which they foster may be fathoms wide until they so far interfere with vital function as to reduce its activity in a notable degree. Then there is something in common between them, just as there is something in common when, being carried a little further, they stop life altogether.

For this is interesting respecting them, in the most potent sense. They all kill when we let them have full play. This is obviously the reason why they are called toxicants and intoxicants. They bear resemblance in action to the poison which once in the history of a past civilization sped on the tip of an arrow from a discharged bow.

The toxicants have variation of action in their early stages. Alcohols excite the mind and quicken the pulses before they depress. Opium excites before it depresses. Tobacco does not in the strict sense excite, but depresses and soothes from the first, so that there are stages, which some persons always feel, when alcohol is antidotal to tobacco. Among those persons who are total abstainers from alcohol few are found who can bear tobacco in the most moderate use of it. Under tobacco the heart seems rapidly to run down in power, and alcohol is called for to whip it up again, also as it seems. The fact is, that the heart is not the organ primarily concerned at all, but the minute vessels at the termination of the arterial circuit. These minute vessels are under a nervous influence by which the passage of blood through them is regulated, and which influence is readily modified by very refined causes acting through the organic or emotional nervous centers. The effect of tobacco on these minute vessels, through the nervous system, is to cause contraction of them as a primary fact, so that the face of the person affected becomes pale and the surface of the body cold, while the heart labors to force on the supply of blood until its own vascular system comes under the influence : then the stomach involuntarily contracts, and, after a time, the voluntary

muscles, deprived of blood, convulse tremulously, or pass into active convulsions, as in tetanus. Alcohol, on the other hand, through its influence on nervous functions, relaxes the vessels of the minute circulation, sets free the heart, reduces the muscular power, and in every particular counteracts the tobacco. When a person receives a stun, or is shocked by some intelligence, or sight, or sound, that thereby stuns him, so that, like Hamlet, he is bechilled

> "Almost to jelly by the act of fear,
> Stands dumb and speaks not,"

he is for the moment in the same state as the man who first tries to smoke tobacco, and who, with pallid face, cold surface, and reeling brain, is to his sense and feeling stricken with all but mortal suffering and prostration. In each of these cases alcohol, for a moment, acts as an antidote not necessarily as the best antidote, but as a fair one. When, therefore, we see a man smoking and drinking, quaffing off the cup of wine or spirit to quiet the qualm which would otherwise be inflicted by the fumes of the cigar or the pipe, we really observe the facts of a most excellently though innocently devised physiological experiment on a living animal. The man, unconsciously to his knowledge, if not to his sensation—unless he be a physiologist—is inducing a balance in the tension of his arterial circuit.

In process of time the nervous system, becoming accustomed to these influences, one or both, in a certain degree tolerates them, for a period. The tolerance while it lasts is an advantage to the habit, and, if the habit were a necessity, it would be a blessing. But the advantage is not permanent. In the end the nutrition of the organic parts which are under the influence of the same nervous regulation is sure to suffer, and in many organizations to suffer rapidly and fatally.

It is probable, if not as yet provable, that all the agents named above produce their specific effect by the influence they exert over the automatic, self-regulating nervous function. In my researches on the action of some substances on the minute circulation, I have been able to differentiate their action by this general rule. The alcohols, the lighter alcohols, including common alcohol, relax the vessels; nicotine constringes; chloroform, by virtue of the chlorine in its composition, constringes; opium relaxes, then constringes; ether relaxes; absinthe, after a time, constringes; chloral hydrate first constringes, and afterward relaxes. From these differences of action the differences of phenomena in the persons affected are explainable. In like manner the ultimate deleterious effects of these agents on the nutrition of the body are explainable. It is a necessary result, for example, that under the long-continued use of alcohol the constantly relaxed and congested vessels should assume a new character and local function; that the parts depending on them for their supplies of blood should be changed from the natural structure to unnatural but definable, and now well-

understood conditions of disease. It is an equally necessary result that under the continued influence of opium the constantly constringed vessels should assume a new local function; that nutrition should be arrested in the parts which those vessels supply with blood; and that the shrunken, impoverished body of the confirmed opium-eater should be an outward and visible sign of the internal changes which are being so assiduously and determinately carried into effect by the narcotic.

When these facts respecting the direct physical action of various toxical agents on the body, through the line of the involuntary nervous system, are understood, they connect, through the same direction, the effects of more refined and much less definable influences. They show how psychological phases are ever at hand to modify nutritive changes: how grief, which shocks and dissevers the organic nervous supply, affects the animal life so deleteriously, exciting and reducing, and sometimes in part disabling altogether parts of the organic nervous track. They indicate how an equable nervous current is conducive to permanent nutritive activity and health, and show physiologically that to laugh and grow fat is after all a mechanical proposition. I must not, however, be tempted away into an inviting field of observation, in which the physical and the metaphysical so neatly blend.

It is worthy of remark that the action of the different toxicants to which I am directing attention, and which are in most common use among members of the human family, have in some cases a similar action, and in other cases a dissimilar action on the members of the lower creation. The alcohols appear to possess a toxical influence throughout all the domain of living animal beings. I can find no animals that escape the immediate action of the alcohols, or the remote effects which occur when the changes excited by the alcohols are often repeated. All our domestic animals come quickly under the ban. Birds and fishes do the same. Chloroform, chloral hydrate, and absinthe seem to exert a similar wide range of action. Tobacco is not so extended in its range. There are animals that can take with perfect impunity a dose of tobacco which would poison three or four men. The goat is an animal which can resist the noxious, but to it innoxious, weed.

Opium can be resisted by certain animals with equal readiness. A pigeon will practically live on opium. A pigeon will swallow with impunity as much solid opium as would throw twelve adult men into the deepest narcotism. Indeed, it is not correct to say that to pigeons opium is in any sense a poison.

The reasons for these exceptions are not clearly made out. The probability is, that the animals which take the intoxicants with so much impunity produce some form of decomposition of the agent in their own bodies, by which the active alkaloidal substance is rendered neutral in effect, or, at all events, is much neutralized.

There is a fact of singular interest in relation to the intoxicants I have now described or named, and which before I proceed further should be carefully noticed. The fact is this: That when the agents produce a definite effect upon a living body, whether it be a human body or the body of an animal that possesses desires and likings, there is caused in that body, after a number of times of practice, a craving or desire for the agent that produced the effect. In man this is so marked that the most repugnant and painful of lessons connected with the first subjection to the agent is soon forgotten in the acquired after-sense of craving or desire. It really matters little which of the intoxicants it is that is learned to be craved for; the craving for it will continue when it has struck an abiding impression. We know this fact well from the wide experience that has been gained of it in the cases of alcohol, tobacco, opium, chloral, hasheesh, absinthe, and arsenic. More incongruous things could scarcely be; incongruous to the senses, to the sensibilities, to the methods of taking, to the result of them; yet the craving for any one of them as it is may be established. The devotee to one will laugh at the devotee to another; each one will consider the other almost insane, and yet each will follow his own course.

Still more curious is it that the substances craved for, which lie quite outside the natural wants of healthy life, may be extended to any number. There is in truth hardly a substance to which the craving may not cling. The distinguished Dr. Huxham had under his observation a man who, after a little practice in the habit of taking it, had a craving for the salt now called bicarbonate of ammonia. The man chewed this salt and swallowed it in the same way as he might have swallowed peppermint lozenges. The effect of the salt was to produce extreme fluidity of the blood of the man, so that he became scorbutic, and to cause loosening of his teeth. It also reduced his strength, and even placed his life in jeopardy; and yet his craving for the ammonia remained unappeased until his danger was so great that the noxious thing had to be withheld altogether. The great Sir Humphry Davy gives another, and it may be still more remarkable, experience in relation to himself. When he was making his wonderful researches with nitrous-oxide gas, he commenced, at first for the mere sake of experiment, to inhale the gas in free quantities. By this process of inhalation he obtained the most delicious of visions. Space seemed to him illimitable, and time extended infinitely, so that coming out of one of these trances he exclaimed: "Nothing exists but thoughts; the universe is composed of impressions, ideas, pleasures, and pains!" In course of time Davy, by the frequent repetition of the process of inhalation, became so infatuated that he could not look at a gasholder, could not look at a person breathing—I am using his own description—without experiencing the urgent sense of desire to once more imbibe his favorite gaseous nectar, and revel in his induced and artificial dreams. How

closely this confession runs, even from the pen of a philosopher, to similar confessions made by many who are not philosophers, respecting another purely chemical intoxicant which is more generally known than Sir Humphry's gas, I need not stay to explain.

An experience, closely allied to the above, occurred to a scientific friend of mine in relation to another intoxicant—namely, chloroform. This gentleman, commencing like Sir Humphry with the inhalation of chloroform for purposes of experiment, at last began daily to inhale a certain measured quantity. In a few days he increased the quantity, and at last discovered, from the intervals of time which elapsed after he commenced each inhalation, that he must have gone off into deep sleep and so have forgotten to note the passage of time. At first the sense of desire to repeat the inhalation alarmed him greatly, but soon the desire overcame all sense of fear, and at last he became a complete devotee to the practice. A break-down in his health led him to communicate his position to his friends, and by the earnest advice and warning of one of them he did at last resolve to abstain altogether. It was a very difficult fight, the odor of the vapor whenever he was near to it recalling most keenly the old desire, and even four years elapsed before he felt himself fully emancipated from the dangerous habit.

The craving attaches itself to other substances than I have hitherto named. I have known it connected with that most nauseous of all medicines, asafœtida ; I have known it strongly attach itself to another medicine, valerian ; and once I knew it attach itself to turpentine. My learned and very good friend the late Dr. Willis, of Barnes, had a patient who acquired the craving for common wood or methylated spirit ; and there are many who have acquired a liking for spirit that is flavored or more than flavored with fusel-oil.

The readiness with which mankind will attach themselves to varied cravings is shown again and on a comparatively large scale in the north of Ireland. In a district there, of which Draper's Town is the center, the eminent Father Mathew labored in his lifetime with such magical effect that he practically converted the whole district to sobriety. A little after his time, and when the influence of his work was fading away, a person came into the district and introduced a new beverage or drink which was not whisky, which was not strong drink, and which, it was said, would do no harm. The bait took, and for over thirty years there has existed in the place I have named a generation or two of ether-drinkers. I have visited this place recently and found the habit still in progress. The ether-drinker tosses off his two or three ounces of common ether, as another man tosses off gin or whisky. He passes rapidly into a state of quick excitement and intoxication, is often senseless for a brief period, and then rapidly regains the sober state. He suffers less from this process in the way of organic disease than he would from a similar number of intoxications from alcohol; but he gains, as he would from alcohol, the same intense crav-

ing, and the craving presents a similar automatic and periodical rule as has been observed in relation to the habitual employment of other active and enticing poisonous compounds.

The nature of these cravings is not more singular than their intensity, when once they have been acquired. The most practiced craver can rarely succeed in explaining upon what the craving really depends. It is an indefinable desire. It is neither thirst, nor hunger, nor pleasure, nor reasonable want. It is rather like a wish to be relieved for the moment of some indescribable sense of pain or discomfort. It is often periodical in its occurrence, and it can, I believe, always be made perfectly periodical, a fact which connects it very closely with the work of the organic nervous system. In a word, in the confirmed craver the work of the organic nervous system, which is singularly periodical and rhythmical in the natural state, is, by these agents, turned into a new direction, and is made to take on a new action which in steady form repeats itself. I have in my house an eight-day clock which, though a century old, does good and faithful work, except at two times in the twenty-four hours, when it goes periodically astray. From some little twist or wear in the machinery, it stops for a moment in the act of striking at one particular stroke of the bell, and on listening to it it seems as if the striking had concluded. Then it strikes feebly and goes on again all right. The working of the involuntary nervous system in health is as automatic and regular as the working of the timepiece; damaged, it is as systematically deranged at particular periods.

The injury from intoxicants, after the first automatic derangement has been established by them, is not to be measured altogether by the first and usual derangement. Unfortunately, the action of the intoxicant extends beyond the mere effect of the craving that springs from it, and involves in its evils structural parts of the animal body. The nutrition of the degraded structures, the sense of muscular and mental fatigue is soon rendered easy of development; and, *pari passu*, the mind, seeking for aid in the influences it likes, finds a supposed aid in the intoxicant. It takes the destructive agent more frequently, thereby establishing a more frequent periodicity of desire, and a more earnest craving. By these combined influences, as is so commonly observed in the intemperate from alcohol, the craving increases as the animal powers decline, and the tendency to death is vastly quickened in its course. To ordinary comprehension, in these instances, the craving and the sinking are the same acts. They become so at last in effect, but their beginnings are quite distinct, and they are, in the strictest expression of fact, distinct phenomena even to the end.

The craving for these intoxicants, so strong in the habituated among men, is not confined to human kind. The beast that can be brought to taste these agents, and that can be affected by them, can be equally well taught to crave for them, and to look out for them also

with automatic and periodical precision. I know of no domestic animal that can not be trained to look out for these agents when the training is conducted with skill and with determination. Like young children, and those persons of later life who have never tasted the agents in any form, nor experienced the sensations which come from them, the lower animals reject them at first, strive against them, and evidently are much disquieted and perplexed by the results which follow their use. But to err is inhuman as well as human, and so the beasts that perish, even they err and learn to like it. In the beast as in the man, the train of events follows the same course. The craving becomes connected almost immediately with deterioration, and at last the two conditions of desire and decay are spun into the same woof, and appear as the same substance.—*Contemporary Review.*

THE BRIGHTNESS AND DISTRIBUTION OF THE FIXED STARS.

By HENRY FARQUHAR.

THOSE who view and admire the starry canopy above us—so fittingly associated, in the oft-quoted language of a great philosopher, with the moral nature of man—can hardly fail to remark how largely their pleasure in the grand prospect is due to the endless variety in its brilliancy. Just as the magnificence of mundane potentates is fully brought out only by the presence of a long train of inferiors more modestly arrayed, so Sirius and Capella would be less splendid had they not a multitude of lesser luminaries to heighten their glory by contrast. And how many hundreds of twinkling points, almost lost in the wide abyss, are there for every star of highest rank! In the proportion of common soldiers to captains, and of captains to corps commanders, this silent host of heaven is not unlike the less stately armies that tread earth instead of ether. And if astronomers have hitherto interested themselves less in questions of precedence and seniority than in the particular spot on the field occupied by each individual in the great array when drawn up for review; if, dropping the figure, differences of luster and the number of stars of the various grades have occupied less of their attention than the comparatively dry details of right-ascension and declination, with all the refinements of precession, nutation, aberration, proper motion, parallax, refraction, etc., affecting these—they are now making some amends for their neglect. The methodical study of stellar brightness belongs almost entirely, however, to the present century, Sir W. Herschel's first paper calling attention to the importance of the subject having appeared in

the publication quaintly termed "Philosophical Transactions" of the London Royal Society in 1796.

Sir W. Herschel here mentions the number of variable stars, constantly increasing under new discoveries, very naturally predicts that closer observation will be likely to show variability in objects previously unsuspected, and recommends that careful comparisons be made from time to time between neighboring stars all over the heavens, so that any change occurring may be at once detected. The original comparisons accompanying this paper have been of but little use, however; they are interesting chiefly as having been the first attempt to introduce scientific methods into this unexplored territory of the astronomical realm. They were made without the aid of any instrument, and consisted of such indefinite statements as—"Star No. 7 about equal to No. 4, and just perceptibly fainter, or decidedly brighter, than No. 12." The difference of brightness which Herschel considered as "just perceptible" seems to have been from one fifth to one fourth of a magnitude.

That his least appreciable difference should have some constant relation to the traditional "magnitude" was to have been expected, bearing in mind what this oldest and most universal scale of reference was intended to express. The fixed stars were assigned to classes of brightness, we learn, before the Christian era; and the very term "magnitudes," used from the first to designate these classes, shows the state of knowledge under which the study had its origin, for, as we now know, the apparently greater size of the brighter stars is due only to imperfections of the eye. All visible stars—all that existed, that is, for the early astronomers of the Mediterranean—were included in six magnitudes, the first containing the dozen or score of brightest stars in the heavens, the second perhaps twice as many ranking next to these, and so on out in gradually increasing circles. The work of the ancients has in this case been well preserved, no modern innovator having been found bold enough to disturb this time-honored system of reckoning. Still, as in the days of the "Father of Astronomy," the two chief stars of Orion serve as examples of the first magnitude, while his Belt and the Dipper in the northern sky furnish types of the second order. But, while astronomy was yet in its infancy, observers had noticed that the stars were not assorted into well-defined orders, in which all the individuals were equally bright; and so, in assigning to a star its magnitude, they would often add that it was "smaller" or "larger" than the mean of that magnitude. They thus practically trebled the number of their classes. The same division into thirds of a magnitude is still employed by those who judge of brightness by eye-estimates, though some are content with dividing into halves, and some undertake to be exact to tenths. Now, even though no scientific precision was attained, or even thought of, in this original apportionment of visible stars among the six magnitudes, to which all later estimates

are adjusted, we would expect to find one principle underlying such a classification, making it that of greatest convenience. It must be just as easy to tell a fourth magnitude star, for instance, from a fifth magnitude as from a third, and there must be as little doubt in distinguishing between the fifth and sixth magnitudes as between the third and second. The numbers expressing magnitudes, then, must actually represent a scale of equal differences as measured by the sensibility of the eye. When an astronomer pays attention to differences of luster, measured also by the sensibility of the eye, but closer than the founders of the science cared to notice, he naturally finds that he can distinguish the same number of intermediate grades between two adjoining magnitudes, whether faint or bright. Herschel's estimates, having been of this character, are, as we have seen, subject to the same condition.

The system of comparisons introduced by Herschel was not followed by later astronomers. Determinations of brightness in which accuracy is sought are now made by means of instruments constructed expressly for the purpose. These instruments, called photometers—measurers of light, that is, their office being to show the amount of light that one star gives as compared with others—add nothing to the discriminating power of the eye, it should be stated. In deciding a question as to which is the brighter of two stars, situated sufficiently near together, no appliance yet invented can assist. But they have these three advantages: they facilitate comparison between faint stars, they furnish a means of comparing distant stars as though side by side, and they give results in a numerical form. That is to say, we get by means of them a definite difference, which may be expressed as a fraction of a magnitude. The magnitude, we see, is no longer regarded as a class, but as a fixed point on a continuous scale; a striking example of that progress of science in all its branches from a qualitative to a quantitative stage, on which philosophers delight so to insist.

But how are measures of light to give us fractions of a magnitude? How can the vague, qualitative relation, the brighter the light the higher the magnitude, become an exact and quantitative one? The discussion of this question may be of use by showing that, even with matters of so uncertain a nature, science does not proceed by guesswork. It is a general law, that the human senses measure ratios and not differences. If I am carrying a small weight, for example, and the addition of an ounce is required to make the burden perceptibly heavier to me, two ounces will have to be added in order that I may notice a difference when I carry twice the weight, and a whole pound when I carry sixteen times the weight. Similarly with the other senses, and, in no slight degree, with the emotions as well. Sensibility to grief and joy, as the experience of every one will attest, becomes feebler with an increase of the amount sustained. So, a faint sound can be heard only in comparative silence, and our footsteps surprise us by their resounding din on the floor of an empty hall, though no louder,

as reflection easily assures us, than when the hall is filled with a bustling multitude. So, though the stars give us their whole light in the daytime, our eye, with the stimulus of an illuminated atmosphere, fails to discover them. This law, first stated by Fechner, is, in mathematical language, the excitement of a nerve varies in arithmetical progression as the exciting cause varies in geometrical progression, or degrees of sensation correspond to logarithms of the quantities perceived. Since, as just shown, the scale of magnitudes is that of equal differences in sensation, it must be at the same time that of equal ratios of light. We must thus have a constant light-ratio between each magnitude and the one next it, and these magnitudes must be logarithms of the quantities of light given, this ratio being taken as the base of our system. In fact, one of the first discoveries in photometry was that such a ratio actually exists; that, for example, if each star rated as third magnitude by good observers gives as much light as $2\frac{1}{2}$ stars of the fourth magnitude, a star of the fourth equals $2\frac{1}{2}$ of the fifth, and so on. Here was a practical confirmation of the character ascribed to ancient estimates of magnitude, and, at the same time, of Fechner's law.

This relation affords us the means of substituting exact measurement for estimates on an ill-defined scale by different observers, among whom a perfect agreement as to standard is out of the question. The idea that each observer has of the meaning of second or fifth magnitude is derived entirely from tradition and confirmed by habit, very much as are his notions of the significance of ordinary adjectives of degree—the only precaution observed being to alter the estimates of antiquity as little as possible, a vague limitation at best. Measures with the photometer depend no less on estimates with the eye, but the determination in them, as to the exact agreement of two lights, is subject to far less uncertainty.

Photometers agree in this particular, whatever their differences in mechanical construction. Seidel, of Munich, who was twelve years in comparing the light of but 208 fixed stars, used an apparatus where two stars seen through a telescope with divided object-glass, each out of focus, were made of the same brightness to the eye by diffusing or concentrating the light of one of them, its half of the object-glass being drawn out or in. The stars thus appeared as two disks, of different sizes but equally bright, and the amount of light given by each was taken as proportionate to the area covered by its disk. The same Dr. Zöllner who has lately become so conspicuous in "spiritualist" investigations, invented a much more convenient style of photometer, with which he made some interesting researches into the comparative light of the planets. Other astronomers, European and American, have also used it. With one of these instruments, belonging to the observatory of Harvard University, Mr. Peirce finished, a few years ago, perhaps the most extensive and methodical photometric work that

has yet been done. His measures included the visible stars, about five hundred in all, of the zone between 40° and 50° of north declination—those passing overhead in the Northern United States and Canada. The light of a kerosene lamp, in Zöllner's photometer, shines through a small round hole in a thin metallic plate, so as to form an imitation of a star, slightly brighter than the real stars with which it is compared. The light of this artificial star, having been polarized by passing through one Nicol prism, is partially cut off by turning another. The proportion of light so cut off depends on the angle of the second prism from parallelism with the first. Having thus found the amounts of light given by two or more stars, as compared with a fixed light, their differences of magnitude are calculated by applying the rule involving logarithms, alluded to above.

Owing to the labor involved in making any large number of photometric comparisons, the less accurate but more convenient method of eye-estimates has not yet been entirely superseded. It becomes necessary, then, to find some way of reducing different observers to one uniform scale, in order to have their work available for determination of variability and questions of distribution. Mr. Peirce, in his "Photometric Researches," recently published by the Harvard College Observatory, has shown that this may be done by the simple process of counting. When we find in any catalogue a star recorded as of magnitude $4\frac{1}{3}$, say, though we can not tell exactly what degree of brightness this figure denotes, we yet know something definite, namely, that this observer classes the star in question as fainter than those he calls 4 and brighter than those he calls $4\frac{2}{3}$. And we know something more: if in the northern hemisphere—a limited part of the heavens must be taken for the purpose, few catalogues being complete in southern stars—he classes 200 stars in all as brighter than $4\frac{1}{3}$, while he calls 25 stars $4\frac{1}{3}$ exactly, he means to tell us that his $4\frac{1}{3}$ magnitude stars would all fall between 200 and 225 on a list of northern stars arranged in order of brightness. It is by considering the order which stars would follow when so arranged, leaving entirely out of view the numbers by which their magnitudes are expressed, that Mr. Peirce brings all observers to a single standard of reference; for he is justified in assuming that each of them attaches the same idea of brightness to the 50th or 150th star in his order, as an assumption of some such nature must be made to have their estimates of any service at all. To reduce to magnitudes these numbers expressing order of arrangement, we have to notice that equal ratios among them correspond to equal differences in magnitude. If we take a good catalogue and find the number of stars in it brighter than 2·0, and add to this number successively the number between 2·0 and 3·0, 3·0 and 4·0, and so on, we shall find that our series of numbers increases geometrically, the common ratio being nearly $3\frac{3}{8}$. This is a remarkable fact, but it is not difficult to account for, on the supposition that the stars are uniformly scat-

tered throughout space, or that portion of space in which visible stars are situated. In this case, the number of them out to any distance from our solar system must vary as the cube of that distance, while their light, supposing no important variations in real size and brightness among them, is inversely proportionate, in the mean, to the square of their distance. And since we have a constant ratio of light between each magnitude and the next, we must accordingly have a constant ratio of mean distance, equal to the square root of this ratio inverted, and a constant ratio of number, equal to the cube of the ratio of distance. Mr. Peirce adopted the ratio $3\frac{3}{8}$. While introducing no perceptible change in the traditional magnitude-scale, except to rid it of irregularities, this number has the convenience of being exactly the cube of $1\frac{1}{2}$. Considering differences in brightness as due exclusively to differences in distance, we may conclude that a star of the second magnitude, for instance, is just half as far again from us as one of the first, and two thirds as far as one of the third. The magnitude of any star, then, is to be regarded as a logarithm of the number expressing its ordinal rank, $3\frac{3}{8}$ being the base of the system. We may thus find to what magnitudes the ordinal numbers, 200 and 225 in the example given, correspond, and take these as the superior and inferior limits of our observer's magnitude $4\frac{1}{3}$. The probable corrected magnitude may be considered as half way between these limits, and we can not be more exact than this in our reduction, because his discrimination has not been close enough to admit of it.

There are, it will thus be seen, three ways of stating the rank of the stars: by magnitudes or other devices to express differences of visual sensibility, by quantities of light, and by positions on a list arranged in order of decreasing luster. These three are reduced to one, through Fechner's law connecting the first two, and the hypothesis of equable distribution connecting the second and third.

But before accepting this hypothesis of equable distribution as part of our knowledge, we must see how well it agrees with the facts. Observation must determine if the "ratio of light" and the "ratio of number" have actually the mathematical relation given above. On the scale adopted by Mr. Peirce, as we have seen, the distance of a star should be two thirds that of one one magnitude fainter, and its light, by the law of the inverse square, $2\frac{1}{4}$ times as great. But the actual ratio of light between successive magnitudes is found by photometric measurement to be not far from $2\frac{1}{2}$; different observers varying from 2·3 to 2·8, but all giving values greater than the theory. By the fact, however, that the ratio thus found is constant or very nearly so for all grades of brightness, we are yet justified, notwithstanding the objection from its too high value, in determining magnitudes by counting, and so clearing individual estimates of much of their uncertainty and irregularity.

The conclusion seems unavoidable that a uniform distribution of

stars does not hold even in the region of space immediately about our solar system. Since the ratio of number is smaller than it should be to correspond to that of light, the density in which the stars are aggregated—if the expression be permitted—must diminish as the distance increases. Our sun is therefore in a part of space more closely filled than are neighboring parts. This is perhaps the most interesting result to which the study of photometry leads us, because it seems so strange at first sight—and even more strange when we remember that the nearest of the other suns is distant from us more than three years' journey of light. Truly, astronomy is without a rival in its special mission, to contradict on every point the evidence of superficial observation. We would most naturally suppose our universe to be as we are told it appeared to a distinguished visitor, when at once

> "The golden sun, in splendor likest heaven,
> Allured his eye; . . .
> . . . . where the great luminary,
> Aloof the vulgar constellations thick,
> That from his lordly eye keep distance due,
> Dispenses light from far."

But this appearance of standing aloof is wholly misleading, and, moreover, as our sun would rank by no means first among the fixed stars if placed at the distance of the nearest of them, and would sink below the third magnitude if removed as far as Sirius, its real insignificance in the stellar firmament is almost as striking as its supremacy in its own planetary system. The reflection is an interesting one, how lamentably the grandest of poems must have suffered had its author been compelled to regard the true proportions of the sidereal universe; but for the true lover of nature, it may be hoped, the glory of the Almighty handiwork will not be lessened through the disappearance from fancy of the universal sovereignty of the sun along the track made for it centuries ago by the vanished delusion that our earth was the unmoved center of all things.

It is very certain that an equable distribution could not hold throughout all space (for an infinite number of stars impartially scattered would, however vast the distances among them, give us a heaven shining like the sun in every part, with heat to correspond) unless, owing to the presence of innumerable dark bodies, or to a discontinuity in the luminiferous ether itself, as some physicists have suggested, light from remote distances is wholly or partly cut off before reaching us. But to this view, though it would agree with all the facts, that of a limitation of our firmament of stars, in extent and number, is generally preferred. That such a limitation exists we have other reasons for believing: prominent among these is the system of distribution which a census of the heavens brings to light. We could not expect

an infinite universe of stars to show everywhere such a uniformity of plan.

How the fixed stars are actually distributed through space, an inquiry into which we are led by study of their number and brightness, it has been but recently found worth while to consider. So long as they were believed to be simply lights set in a hollow revolving structure that divided the waters beneath from the waters above; so long as the idea of the "firmament" retained the association with solidity that now only remains in the word; so long as the "spangled heavens, a shining frame" was a reality of opinion and not an unmeaning archaism of poetry—this question was never heard. No significance could attach to it, and it excited no curiosity. But when this solid celestial framework was broken up by the discovery of the earth's rotation, and its lights scattered afar on the deep ocean of unbounded space, when contemplation of the beautiful adjustments and proportions of our solar system had suggested the hope of discovering the same harmonies throughout the universe, it began to be asked if some of these far-distant orbs, or perhaps the mighty whole, our sun and its attendant planets included, were not connected in a system of similar character. Kant was one of the first to advance this idea. The elder Herschel, contenting himself with a working hypothesis to give form to his observations, supposed our firmament to be a mighty cluster of stars equally distributed within finite limits, so that the number visible in the field of his great reflector at any pointing would show the extent of occupied space in that direction; and he undertook to gauge the depths and discover the shape of this cluster by counting telescopic fields in different parts of the sky. The elder Struve considered the density of the stars as varying with the distance from the Milky Way, as does that of the atmosphere with its distance from the earth's surface; being equal in parallel plans.* Argelander, of Bonn, relieved his laborious task of cataloguing over 300,000 northern stars, by investigation into the subject; Mr. Proctor has devoted to it numerous memoirs and popular lectures, and speaks of it as his chief incentive to the labor of constructing his set of twelve star maps; Mr. Peirce gives it considerable space in his "Photometric Researches." From these sources we have a few conjectures and a few facts.

The richest parts of the sky, in bright and faint stars alike, are almost all about the Milky Way. This stream of suffused light follows, with some irregularities, the course of a great circle; and toward the plane of this circle, passing not very far, perhaps, from the sun, stars at all distances appear to become more densely packed. The Milky Way itself is evidence of this for the faintest magnitudes; and Herschel's star-gauges, from which he inferred for our cluster the shape of a disk or lens, give the comparison in a numerical form.

* Professor Newcomb's account of these researches and speculations, in his "Popular Astronomy," pages 462–476, is full and interesting.

Argelander's gauges show the same concentration in telescopic stars brighter than the tenth magnitude, and it is even more plainly to be made out from Mr. Proctor's chart of his great catalogue. If parallel to the great circle of the Milky Way two small circles be passed, each at a distance from it of 30°, having between them a broad belt about the celestial sphere somewhat like the torrid zone on the earth's surface, we shall leave two spherical caps whose united area will exactly equal that of the belt — just one hemisphere. From Argelander's gauges it may be calculated that the number of stars inside these 30° circles is to that outside nearly as 2½ to 1, for stars of the ninth magnitude, and about as 2 to 1 for the eighth, diminishing with brighter stars. This condensation increases without interruption, to the Milky Way itself. The law holds also with stars visible to the naked eye, though not so conspicuously; for these, Mr. Peirce found the same ratio to be only as 4 to 3. He was also surprised to see that the stars were very little more numerous in the track of the Milky Way than at a distance of 20° from it, the decrease in density appearing almost suddenly about 30°. But as we approach the sun, the rate of condensation becomes greater again. Of the twenty stars classed as first magnitude by the best observers, fifteen are within the 30° circles; and of the five outside, but two, Arcturus and one far southern star, are equal in brightness to the average of the twenty. We have no right, however, unless we are dealing generally with a very great number of stars, to take light as a reliable indication of distance. Of our twelve nearest neighbors yet recognized, being all that have a parallax greater than one sixth of a second, and distant from us less than twenty years' journey of light, four are telescopic stars, to which attention was attracted by their large proper motion. Ten stars out of these twelve, it should therefore be added, are either in the Milky Way or within 15° of it. The exceptions are two minute stars in Ursa Major.

Will these facts enable us to decide what is the actual form of the immense cluster of stars in which our sun holds so humble a rank? We may conclude from them, with safety, that the strongly marked and surprising concentration of brightest and nearest stars in the galactic plane is irreconcilable with a generally prevailing uniform distribution, and agrees hardly better with Struve's theory of condensation in parallel planes. For this theory, it will be seen, requires a more decided concentration with a greater distance, the planes of equal density appearing to approach the galactic circle and each other as do the parallel lines of a perspective drawing. We do see some tendency of this kind in telescopic magnitudes, so that we might suppose that Struve's theory began to express the facts at the distance of the faintest visible stars—unless it could be shown that the density of aggregation in the central plane also varies at different distances. In Mr. Peirce's opinion, photometric observations have proved that this density increases from the seventh to the ninth magnitude, and that there-

fore the idea of the Milky Way itself as a vast ring of closest aggregation, including a more sparsely filled region, thus giving to the whole cluster, could it be seen laterally from a sufficient distance, an appearance not unlike that of the annular nebula in Lyra, is well founded. He also finds reason for supposing a similar but independent arrangement of the brightest stars, in the peculiar localization of the nearest of them, and the sudden falling off in density at about 30° from the galactic circle, above remarked—other systems of condensation requiring gradual changes. The true figure, if his reasoning is to be trusted, would therefore be a small ring of maximum density near the center of a very large one.* Such speculations are, however, it is hardly necessary to say, very uncertain.

It is not easy to make out, from the general distribution of the stars, that our sun is in one direction rather than another from the center of the sidereal system, and there is even some doubt about the position which some astronomers give us, on the northern side of the plane of the Milky Way. Indeed, beyond the prevailing condensation toward this plane, it seems that no important general law governing star aggregation has yet been found. Mr. Proctor's services in calling attention to the grouping of certain portions of the heavens in subordinate systems having a common "star-drift," should not be overlooked ; but his discovery that a large part of the southern hemisphere is particularly rich in stars † can not be admitted for several reasons : 1. Behrmann's catalogue of southern stars, in which magnitudes were observed with particular care, shows nothing of the sort ; 2. Mr. Proctor's own maps show nothing of the sort, for stars brighter than the sixth magnitude ; and it is far less credible that an anomalous law of distribution holds over a wide area, affecting but this one order of brightness, than that those who observed this part of the heavens included more and fainter stars in their sixth magnitude than did northern observers ; 3. Mr. Proctor's own maps show that the boundary of his "rich region" is the Tropic of Capricorn ; and it is far less credible that an artificial circle should limit any law of distribution than that the whole difference is due to the fact that this tropic was also the northern boundary of La Caille's observations, the source, in all probability, whence the magnitudes of Mr. Proctor's stars were originally derived. Observers, in fact, are particularly likely to differ in estimating the extent of the sixth magnitude, for it seems to have been agreed by general consent that this magnitude shall include all stars to be seen with the unaided eye on the clearest nights, and differ-

* "Photometric Researches," pages 175–178. The sun, it would seem, is to be considered as in a region of exceptional rarity as compared with other regions through which the galactic plane passes, and at the same time of exceptional density when the comparison includes stars remote from this plane.

† Most positively stated in a lecture before the Royal Institution, May, 1870 ; also in the introduction to his "Star Atlas."

ences of climate and of individual eye-sight affect this considerably. Argelander, and after him Heis, catalogued all the stars visible to their eyes ; their numbers, for the whole northern hemisphere, were 2,350 and 3,936 respectively. Heis, must therefore, have seen stars at least four tenths of a magnitude fainter than Argelander's faintest. La Caille's eye must also have been sharper than the average ; and, if Mr. Proctor had thought to apply the test of enumeration to the different magnitudes in different parts of the sky, this explanation would doubtless have occurred to him, and nothing have been heard of his remarkable "rich region." His observation is valuable, certainly ; but only by showing the undeveloped state of the whole subject, and the precautions necessary before venturing conclusions on it.

The search for a common center, about which the uncounted millions of stars composing the galactic cluster may revolve, has tempted many investigators, but it can not be said as yet to have proved altogether successful. Mädler, by calculations from the proper motions of stars in different parts of the heavens, sought to locate it among the Pleiades ; some later astronomers have preferred the Sword of Perseus ; Mr. Maxwell Hall has just decided, and informed the Astronomical Society of England, that the universe turns about the South Elbow of Andromeda. The proof advanced is always incomplete, resting on assumptions not generally admitted ; and when we remember that the gravitative force exerted by the fixed stars on one another is so small that to keep the nearest of them from falling to the sun, supposing no counterbalancing attractions, an angular velocity of but one second of arc in eighty years is needed ; that the proper motions to be explained are often far larger than this ; that the distance of the attracting center must be many times that of the nearest fixed star ; and that the heavens give no sign of any preëminent body or group of bodies to which we may ascribe the enormous attractive power necessary to control these motions—the skepticism of many astronomers as to the universal center seems excusable.

It must be admitted, then, that but little of the true character of our sidereal system is known to us, and that all speculation upon it rests as yet on a very insecure foundation. But, as the sudden development of spectrum analysis has shown, matters of pure conjecture to-day may become entirely settled to-morrow ; and it may reasonably be hoped that the secrets of this domain, if due interest be taken in them, will not much longer elude the search of scientific explorers.

FOOD AND FEEDING.

By Sir HENRY THOMPSON.

II.

THE remainder of the second portion of my subject—viz., the preparation of food, which ought to have been concluded in the first paper—must appear, although in very brief terms, at the commencement of this. After which I shall proceed to consider the chief object of the present article, viz., the combination and service of dishes to form a meal, especially in relation to dinners and their adjuncts.

I think it may be said that soups, whether clear (that is, prepared from the juices of meat and vegetables only), or thick (that is, *purées* of animal or vegetable matters), are far too lightly esteemed by most classes in England, while they are almost unknown to the working-man. For the latter they might furnish an important, cheap, and savory dish; by the former they are too often regarded as the mere prelude to a meal, to be swallowed hastily, or disregarded altogether as mostly unworthy of attention. The great variety of vegetable *purées*, which can be easily made and blended with light animal broths, admits of daily change in the matter of soup to a remarkable extent, and affords scope for taste in the selection and combination of flavors. The use of fresh vegetables in abundance—such as carrots, turnips, artichokes, celery, cabbage, sorrel, leeks, and onions—renders such soups wholesome and appetizing. The supply of garden produce ought in this country to be singularly plentiful; and, owing to the unrivaled means of transport, all common vegetables ought to be obtained fresh in every part of London. The contrary, however, is unhappily the fact. It is a matter of extreme regret that vegetables, dried and compressed after a modern method, should be so much used as they are for soup, by hotel-keepers and other caterers for the public. Unquestionably useful as these dried products are on board ship and to travelers camping out, to employ them at home when fresh can be had is the result of sheer indolence or of gross ignorance. All the finest qualities of scent and flavor, with some of the fresh juices, are lost in the drying process; and the infusions of preserved vegetables no more resemble a freshly made odoriferous soup, than a cup of that thick, brown, odorless, insipid mixture, consisting of some bottled "essence" dissolved in hot water, and now supplied as coffee at most railway stations and hotels in this country, resembles the recently made infusion of the freshly roasted berry. It says little for the taste of our countrymen that such imperfect imitations are so generally tolerated without complaint.

The value of the gridiron is, perhaps, nowhere better understood than in England, especially in relation to chops, steak, and kidney.

Still it is not quite so widely appreciated as it deserves to be in the preparation of many a small dish of fish, fowl, and meat, to say nothing of a grilled mushroom, either alone or as an accompaniment to any of them. And it may be worth while, perhaps, remarking that the sauce *par excellence* for broils is mushroom ketchup; and the garnish cool lettuce, watercress, or endive. And this suggests a word or two on the important addition which may be made to most small dishes of animal food under the title of "garnish." Whether it be a small fillet, braised or roasted, or a portion thereof broiled; a fricandeau, or the choice end of a neck of mutton made compact by shortening the bones; or a small loin, or a dish of trimmed neck cutlets, or a choice portion of broiled rumpsteak; a couple of sweetbreads, poultry, pigeon, or what not—the garnish should be a matter of consideration. Whether the dish be carved on the family table, as it rarely fails to be when its head is interested in the *cuisine*, or whether it is handed in the presence of guests, the quality and the appearance of the dish greatly depend on the garnish. According to the meat, may be added with a view both to taste and appearance, some of the following—*purées* of sorrel, spinach, and other greens, of turnips, and of potatoes plain, in shapes, or in croquettes; cut carrots, peas, beans, endive, sprouts, and other green vegetables; stewed onions, small or Spanish; cucumbers, tomatoes, macaroni in all forms; sometimes a few sultanas boiled, mushrooms, olives, truffles. In the same way chestnuts are admirable, whole, boiled, or roasted, and as a *purée* freely served, especially in winter when vegetables are scarce; serving also as farce for fowls and turkeys. While such vegetables as green peas, French and young broad beans, celery and celeriac, asparagus, seakale, cauliflower, spinach, artichokes, vegetable marrows, etc., are worth procuring in their best and freshest condition, to prepare with especial care as separate dishes.

It is doubtful whether fish is esteemed so highly as an aliment as its nutritious qualities entitle it to be, while it offers great opportunity for agreeable variety in treatment. As a general observation, it may be said that in preparing it for table sufficient trouble is not taken to remove some portion of the bones; this can be advantageously done by a clever cook without disfiguring or injuring the fish. Sauces should be appropriately served: for example, the fat sauces, as *hollandaise* and other forms of melted butter, are an appropriate complement of hot boiled fish, while *mayonnaise* is similarly related to cold. These and their variations, which are numerous, may also accompany both broiled and fried fish, but these are often more wholesome and agreeable when served with only a squeeze of lemon-juice, and a few grains of the zest, if approved, when a fresh green lemon is not to be had, and it rarely can be here. But the juice of the mushroom is preferred, and no doubt justly, by some. Endless variations and additions may be made according to taste on these principles. But there

is another no less important principle, viz., that the fish itself often furnishes a sauce from its own juices, more appropriate than some of the complicated and not very digestible mixtures prepared by the cook. Thus "melted butter"—which is regarded as essentially an English sauce—when intended to accompany fish, should not be, as it almost invariably is, a carelessly made compound of butter, flour, and water; but in place of the last-named ingredient there should be a concentrated liquor made from the trimmings of the fish itself, with the addition of a few drops of lemon-juice, and strengthened if necessary from other sources, as from shell-fish of some kind. Thus an every-day sauce of wholesome and agreeable quality is easily made; it finds its highest expression in that admirable dish, the sole with *sauce au vin blanc* of the French, or, as associated with shell-fish, in the *sole à la normande*. Some fish furnish their own sauce in a still simpler manner, of which an illustration no less striking is at hand in the easiest but best mode of cooking a red mullet, viz., baking it, and securing the gravy of delicious flavor which issues abundantly from the fish, chiefly from the liver. as its only sauce.

Passing rapidly on without naming the ordinary and well-known service of cold meats, fresh and preserved, poultry and game, open or under paste in some form, to be found in profusion on table or sideboard, and in which this country is unrivaled, a hint or two relating to some lighter cold *entrées* may be suggested. It is scarcely possible to treat these apart from the salad which, admirable by itself, also forms the natural garnish for cold dishes. A simple aspic jelly, little more than the *consommé* of yesterday flavored with a little lemon-peel and tarragon vinegar, furnishes another form of garnish, or a basis for presenting choice morsels in tempting forms, such as poultry-livers, ox-palates, quenelles, fillets of game, chicken, wild fowl, fish, prawns, etc., associated with a well-made salad. On this system an enterprising cook can furnish many changes of light but excellent nutritious dishes.

On salad so much has been written, that one might suppose, as of many other culinary productions, that to make a good one was the result of some difficult and complicated process, instead of being simple and easy to a degree. The materials must be secured fresh, are not to be too numerous and diverse, must be well cleansed and washed without handling, and all water removed as far as possible. It should be made by the hostess, or by some member of the family, immediately before the meal, and be kept cool until wanted. Very few servants can be trusted to execute the simple details involved in cross-cutting the lettuce, endive, or what not, but two or three times in a roomy salad-bowl ; in placing one saltspoonful of salt and half that quantity of pepper in a tablespoon, which is to be filled three times consecutively with the best fresh olive-oil, stirring each briskly until the condiments have been thoroughly mixed, and at the same time

distributed over the salad. This is next to be tossed well, but lightly, until every portion glistens, scattering meantime a little finely chopped fresh tarragon and chervil, with a few atoms of chives, over the whole. Lastly, but only immediately before serving, one small tablespoonful of mild French vinegar is to be sprinkled over all, followed by another tossing of the salad.* The uncooked tomato, itself the prince of salads, may be sliced and similarly treated for separate service, or added to the former, equally for taste and appearance. Cold boiled asparagus served with a *mayonnaise* forms a dish, of its kind, not to be surpassed. At present ranking, when the quality is fine, as an expensive luxury, there is no reason why, with the improved methods of cultivating this delicious and wholesome vegetable, it should not be produced in great abundance, and for less than half its present price.† As to the manifold green stuffs which, changing with the season, may be presented as salad, their name is legion ; and their choice must be left to the eater's judgment, fancy, and digestion, all of which vary greatly.

The combination of dishes to form a meal now demands our consideration. The occupations of man in a civilized state, no less than the natural suggestions of his appetite, require stated and regular times for feeding. But the number of these set apart in the twenty-four hours differs considerably among different peoples and classes. Taking a general view of the subject, it may be said that there are three principal systems to which all varieties of habit may be reduced. From an English point of view, these may be regarded as—

1. The Continental system of two meals a day.
2. The system of provincial life (Great Britain), or four meals.
3. The system of town life (Great Britain), or three meals.

1. In the Continental system, the slight refreshment served in the early morning, in the form of coffee or chocolate, with a rusk or a morsel of bread, does not amount to a meal. It is only a dish, and that a light one, and not a combination of dishes, which is then taken. At or about noon a substantial meal, the *déjeuner*, is served ; and at six or seven o'clock, an ample dinner. Such is the two-meal system, and it appears to answer well throughout the west and south of Europe.

2. What I have termed the provincial system consists of a substantial breakfast at eight or nine, a dinner at one or two, a light tea about five, and a supper at nine or ten. It is this which is popular throughout our own provincial districts, and also among middle-class society of our northern districts throughout both town and country. The habits also of the great German nation correspond more to this than to the first-named system.

* A salad for five or six persons is supposed.

† On this subject, and also on salad culture, see "The Parks and Gardens of Paris," by W. Robinson, F. L. S., p. 468, *et seq.*, second edition. Macmillan, 1878.

3. The prevailing system of London, and of the numerous English families throughout the country whose habits are formed from partial residence in town, or by more or less intimate acquaintance with town life, is that of three meals daily. In general terms the breakfast takes place between eight and ten; the lunch from one to two; the dinner from half-past six to eight.

In all cases each meal has its own specific character. Thus, here, breakfast is the most irregular in its service, and least of all demands general and intimate coherence of the party assembled. Individual interests concerned in the letter-bag, in the morning news, in plans for the day, in cares of coming business, etc., are respected. Provision for acknowledged dietetic peculiarities on the part of individuals is not forgotten, and every one comes or goes as he pleases.

At lunch the assembly is still somewhat uncertain. Thus some members of the family are absent without remark; intimate friends may appear without special invitation; while those less intimate can be asked with small ceremony. Occupations of pleasure or of business still press for pursuit during the afternoon, and the meal for such may not be too substantial. It should suffice amply to support activity; it should never be so considerable as to impair it.

The last meal of the three, dinner, has characters wholly different from the preceding. The prime occupations of the day are over; the guests are known and numbered; the sentiment is one of reunion after the dispersion of the day—of relaxation after its labors, sports, or other active pleasures. Whatever economy of time may have been necessary in relation to the foregoing meals, all trace of hurry should disappear at dinner. A like feeling makes the supper of the "provincial" system a similarly easy and enjoyable meal. And all this is equally true of dinner, whether it unites the family only, or brings an addition of guests. General conversation: the events and personal incidents of the day, the current topics of the hour, are discussed in a light spirit, such as is compatible with proper attention to the dishes provided. All that follows late dinner should for the most part be amusement—it may be at the theatre, an evening party, or a quiet evening at home. There should be ample time, however, for every coming engagement, and security for some intervening rest for digestion. Dinner, then, is the only meal which—as the greater includes the less—need be discussed in the third part of our subject, which claims to treat of custom and art in combining dishes to form a repast. With the requirements and under the circumstances just specified, it should not be a heavy meal, but it should be sufficing. No one after dinner should feel satiety or repletion, with a sense of repugnance at the idea of eating more; but all should still enjoy the conviction that a good meal furnishes delightful and refreshing occupation.

Dinners are of two kinds—the ordinary meal of the family, and the dinner to which guests are invited. There is a third dinner in

this country, of common—too common—occurrence, viz., the public dinner, which is essentially a British institution, and can not be passed by in silence.

The late dinner should never include children. It is a meal which is in every way unsuited to them, and they are quite unfitted to take part in its functions ; besides, the four-meal system is better adapted to their requirements of growth and digestion in early life. A family dinner may usually consist of a soup, fish, *entrée*, roast, and sweet ; the *entrée* may even be omitted ; on the other hand, if the meal is required to be more substantial, a joint may be served in addition after the fish ; but this should be very rarely necessary. A dish of vegetables may be advantageously placed before or after the roast, according to circumstances ; and supplementary vegetables should be always at hand.

The *rationale* of the initial soup has often been discussed : some regard it as calculated to diminish digestive power, on the theory that so much fluid taken at first dilutes the gastric juices. But there appears to be no foundation for this belief ; a clear soup, or the fluid constituents of a *purée*, disappear almost immediately after entering the stomach, being absorbed by the proper vessels, and in no way interfere with the gastric juice which is stored in its appropriate cells ready for action. The habit of commencing dinner with soup has without doubt its origin in the fact that aliment in this fluid form—in fact, ready digested—soon enters the blood and rapidly refreshes the hungry man, who, after a considerable fast and much activity, sits down with a sense of exhaustion to commence his principal meal. In two or three minutes after taking a plate of good warm *consommé*, the feeling of exhaustion disappears, and irritability gives way to the gradually rising sense of good-fellowship with the circle. Some persons have the custom of allaying exhaustion with a glass of sherry before food—a gastronomic no less than a physiological blunder, injuring the stomach and depraving the palate. The soup introduces at once into the system a small installment of ready-digested food, and saves the short period of time which must be spent by the stomach in deriving some portion of nutriment from solid aliment, as well as indirectly strengthening the organ of digestion itself for its forthcoming duties. Few will be found to dispute the second place in order to fish, although this arrangement is in some quarters an open question : its discussion, however, can scarcely be regarded as within the limit of our space. The third dish should consist of the chief meat, the joint, if desired ; if not, one of the smaller dishes of meat, such as fricandeau, cutlets, *filet*, or sweetbread, before spoken of, well garnished, will be appropriate, and to many preferable. Next the well-roasted bird—of game or poultry—accompanied or followed by salad, and a dish of choice vegetables. Then one light simple sweet, for those who take it, and a slight savory biscuit or morsel of

cheese completes the repast. Such a meal contains within its limits all that can be desired for daily enjoyment and use. If well and liberally served, it is complete in every sense of the word. Dessert and its extent is a matter of individual taste; of wines, coffee, and liqueurs I shall speak hereafter.

A word about *hors-d'œuvres.* It is well known that the custom exists to a very wide extent among Continental nations of commencing either mid-day *déjeuner* or dinner by eating small portions of cold pickled fish, vegetables, of highly-flavored sausage thinly sliced, etc., to serve, it is said, as a whet to appetite. This custom reaches its highest development in the *zakuska* of the Russian, which, consisting of numerous delicacies of the kind mentioned, is sometimes to be found occupying a table in an anteroom to be passed between the drawing-room and dining-room; or, and more commonly, spread on the sideboard of the latter. The Russian eats a little from three or four dishes at least, and "qualifies" with a glass of strong grain-spirit (*vodka*) or of some liqueur before taking his place at the table. Among these savory preliminaries may often be found caviare in its fresh state, gray, pearly, succulent, and delicate, of which most of the caviare found in this country is, speaking from personal experience of both, but as the shadow to the substance.

I have no hesitation in saying, after much consideration of the practice of thus commencing a meal, that it has no *raison d'être* for persons with healthy appetite and digestion. For them, both pickled food and spirit are undesirable, at any rate on an empty stomach. And the *hors-d'œuvres*, although attempts to transplant them here are often made, happily do not, as far as I have observed, thrive on our soil. They have been introduced here chiefly, I think, because their presence, being demanded by foreign gastronomic taste, is supposed to be, therefore, necessarily correct. But the active exercise and athletic habits of the Englishman, his activity of body and mind in commercial pursuits, all tend to bring him to the dinner-table wanting food rather than appetite, and in no mind to ask for "whets" to increase it. Among idle men, whose heavy lunch, liberally accompanied with wine and not followed by exercise, has barely disappeared from the stomach at the hour of dinner, a piquant prelude as stimulus of appetite is more appreciated. Hence the original invention of *hors-d'œuvres*; and their appearance in a very much slighter and more delicate form than that which has been described, still to be observed in connection with the chief repasts of the Latin races. The one plate which heralds dinner, indigenous to our country, is also one of its own best products—the oyster. But this is scarcely a *hors-d'œuvre.* In itself a single service of exquisite quality, served with attendant graces of delicate French vinegar, brown bread and butter, and a glass of light chablis for those who take it, the half-dozen natives occupying the hollow shells, and bathed in their own liquor, hold rank of a very

different kind to that of a miscellaneous assortment of tidbits alluded to. Oysters are, in fact, the first dish of dinner and not its precursor; the first chapter, and not the advertisement. And this brings us to the dinner of invitation.

And of this dinner there are two very distinct kinds: First, there is the little dinner of six or eight guests, carefully selected for their own specific qualities, and combined with judgment to obtain an harmonious and successful result. The ingredients of a small party, like the ingredients of a dish, must be well chosen to make it "complete." Such are the first conditions to be attained in order to achieve the highest perfection in dining. Secondly, there is the dinner of society, which is necessarily large; the number of guests varying from twelve to twenty-four.

The characteristics of the first dinner are—comfort, excellence, simplicity, and good taste. Those of the second are—the conventional standard of quality, some profusion of supply, suitable display in ornament and service.

It must be admitted that, with the large circle of acquaintances so commonly regarded as essential to existence in modern life, large dinners only enable us to repay our dining debts, and exercise the hospitality which position demands. With a strong preference, then, for the little dinners, it must be admitted that the larger banquet is a necessary institution; and therefore we have only to consider now how to make the best of it.

No doubt the large dinner has greatly improved of late; but it has by no means universally arrived at perfection. Only a few years ago excellence in quality and good taste in *cuisine* were often sacrificed in the endeavor to make a profuse display. Hence, abundance without reason, and combinations without judgment, were found coexisting with complete indifference to comfort in the matters of draughts, ventilation, temperature, and consumption of time. Who among the diners-out of middle age has not encountered many a time an entertainment with some such programme as the following: one of an order which, it is to be feared, is not even yet quite extinct?—

Eighteen or twenty guests enter a room adapted at most to a dinner of twelve. It is lighted with gas; the chief available space being occupied by the table, surrounding which is a narrow lane, barely sufficing for the circulation of servants. Directly—perhaps after oysters—appear turtle soups, thick and clear. A *consommé* is to be had on demand, but so unexpected a choice astonishes the servitor, who brings it after some delay, and cold; with it, punch. Following, arrive the fish—salmon and turbot, one or both, smothered in thick lobster sauce: sherry. Four *entrées* promenade the circuit in single file, whereof the first was always oyster patties; after which came mutton or lamb cutlets, a vol-au-vent, etc.: hock and champagne. Three quarters of an hour at least, perhaps an hour, having now elapsed,

the saddle or haunch of mutton arrives, of which gentlemen who have patiently waited get satisfactory slices, and currant jelly, with cold vegetables or a heavy, flabby salad. Then come boiled fowls and tongue, or a turkey with heavy forcemeat; a slice of ham and so on, up to game, followed by hot, substantial pudding, three or four other sweets, including an iced pudding; wines in variety, more or less appropriate; to be followed by a *pâté de foie gras*, more salad, biscuits and cheese. Again, two ices, and liqueurs. Then an array of decanters, and the first appearance of red wine; a prodigious dessert of all things in and out of season, but particularly those which are out of season, as being the more costly. General circulation of waiters, handing each dish in turn to everybody, under a running fire of negatives, a ceremonial of ten or fifteen minutes' duration, to say the least. Circulation of decanters; general rustle of silks, disappearance of the ladies; and first change of seat, precisely two hours and a half after originally taking it. It may be hoped that a charming companion on either side has beguiled and shortened a term which otherwise must have been felt a little long. Now the general closing up of men to host, and reassembling of decanters; age and qualities of wine, recommendation of vintages. Coffee which is neither black nor hot. Joining the ladies; service of gunpowder tea, fatal to the coming night's rest if taken in a moment of forgetfulness; and carriages announced.

Admitted that such an exhibition is impossible now in any reasonable English circle, it nevertheless corresponds very closely in style with that of the public dinner; a state of things without excuse. And the large private dinner is still generally too long, the *menu* too pretentious. Let me, however, be permitted to record, equally in proof of growing taste and as grateful personal duty, how many admirable exceptions to the prevailing custom are now afforded. Then, of course, it must be understood that, while the dinner for six or eight persons is designed as an harmonious whole of few, well-chosen dishes, all of which are intended to be eaten in their order, the *menu* of the larger party must offer various dishes for choice to meet the differing tastes of more numerous guests, and it must therefore be larger. Let us see how this is to be met. First, the soups: it is the custom to offer a *consommé*, which ought to be perfect in clearness, color, and savor, and to be served perfectly hot; containing vegetables, etc., variously treated—doubtless the best commencement, as it is the key-note, of the dinner; revealing also, as it does nine times out of ten, the caliber of the cook to whose talent the guest is intrusted. But there is mostly an alternative of "white soup," and this is almost always a mistake. Many persons refuse it, and they are right, containing, as it generally does, a considerable proportion of cream—an injudicious beginning, when there is much variety to follow; excellent sometimes as one of three or four dishes, but dangerous otherwise to the guest who has not an exceptionally powerful digestion. But, sup-

pose oysters, vinegar, and chablis have just been swallowed! A brown *purée*, as of game, or one of green vegetables, less frequently met with, would be far safer. Two fish, of course, should always be served; as, for example, a slice of Severn or Christchurch salmon, just arrived from the water, for its own sake; and a fillet of white fish for the sake of its sauce and garnish, which should be therefore perfect. The next dish is, in London, a question under discussion, viz., the question of precedence to an *entrée*, or to the *pièce de résistance*. The custom has been to postpone the appearance of the latter until lighter dishes have been dispatched or declined. If, however, the English joint is required at a meal already comprehensive in the matter of dishes, and taken at a late hour, it seems more reasonable to serve it next to the fish, when those who demand a slice of meat may be expected to have an appropriate appetite, which will certainly be impaired, equally by accepting the *entrées*, or fasting partially without them. After the joint, two light *entrées* may follow, and these must necessarily be either in themselves peculiarly tempting morsels, or products of culinary skill, offering inducement to the palate rather than to an appetite which is no longer keen. Then the best roast possible in season, and a salad; a first-rate vegetable, two choice sweets, one of which may be iced; a light savory biscuit or a morsel of fine barely salted caviare, which may be procured in one or two places at most in town, will complete the dinner. For dessert, the finest fruits in season to grace the table and for light amusement after; or simply nuts in variety, and dry biscuits; nothing between the two is tolerable, and little more than the latter is really wanted; only for decorative purposes fruit equals flowers. But it may be admitted that the diminished number of sweet *entremets* strengthens the plea for a supply of delicious fruits, rendering the dessert useful and agreeable as well as ornamental.

And, now that dessert is over, let me say that I do not admit the charge sometimes intimated, although delicately, by foreigners, of a too obvious proclivity to self-indulgence on the part of Englishmen, in permitting the ladies to leave the table without escort to the drawing-room. The old custom of staying half an hour, or even an hour afterward, to drink wine, which is doubtless a remnant of barbarism, has long been considered indefensible. Still, the separation of the party into two portions for fifteen or twenty minutes is useful to both, and leads perhaps more completely to a general mixture of elements on reunion after than is attained by the return of the original pairs together. Whether this be so or not, the ladies have a short interval for the interchange of hearsays and ideas relative to matters chiefly concerning their special interests; while the men enjoy that indispensable finish to a good dinner, an irreproachable cup of coffee and a cigarette, and the sooner they arrive the better. With the small dinners of men it can scarcely too quickly follow the last service.

But marked by a special character are some dinners, which may be either small or large, in relation to the number of guests, but which are necessarily limited as regards the variety of aliments served. I refer to dinners at which either turtle or fish predominates. In accordance with a principle already enunciated, a bowl of substantial stock, containing four or five broad flakes of the gelatinous product, often miscalled "fat," which alone represents the turtle in the compound, is not a judicious prelude to a dinner arranged according to the orthodox programme, and offering the usual variety. A lover of turtle indulges freely in the soup, both thick and clear, making it in fact an important installment of his repast; and he desires, with or without some slight interlude, to meet the favorite food again in the form of an *entrée*. After so substantial a commencement, the dinner should be completed chiefly by poultry, and game if in season, and for the most part by dishes which are grilled or roast, in contrast to the succulent morsels which have preceded.

The fish dinner, also an occasional departure from daily routine, is acceptable, and gratifies the taste for that delicate and pleasant food in considerable variety. But, if so indulged, very few dishes ought to appear subsequently. It is a curious fact that the traditional bacon and beans, which appear toward the close of a Greenwich whitebait dinner, should afford another illustration of undesigned compliance with the natural law referred to at the outset, the bacon furnishing complementary fat to supply its notable absence in fish.

The enjoyment of a curry—and when skillfully made it is almost universally admitted to be one of the most attractive combinations which can be offered to the senses of taste and smell—is only possible at a limited repast. When freely eaten, very little is acceptable to the palate afterward, exhausted as it is by the pervading fragrance of the spice and other adjuncts. Hence a curry should form the climax of a short series of dishes leading up to it: when presented, as it sometimes is, among the *entrées* of a first course, it is wholly out of place.

Here we may appropriately take a rapid glance at the characteristics of the feast where the guests are few in number.

The small dinner-party should be seated at a round or oval table, large enough for personal comfort, small enough to admit of conversation in any direction without effort. The table should of course be furnished with taste, but is not to be encumbered with ornaments, floral or other, capable of obstructing sight and sound. A perfect *consommé*, a choice of two fish, a *filet* or a châteaubriand, a *gigot* or a fricandeau; followed by a chaudfroid, a *crème de volaille garni*, a roast and salad, a choice vegetable, and an iced *soufflé* or *charlotte;* and in summer a *macédoine* of fresh fruits in an old china family bowl, if there is one; and, lastly, a savory biscuit, accompanying vegetables and appropriate wines, may be regarded as furnishing a

scheme for such a party, or a theme of which the variations are endless. Seven or eight guests can thus be brought into close contact: with a larger number the party is apt to form two coteries, one on each side of the host. The number is a good one also in relation to the commissariat department—eight persons being well supplied by an *entrée* in one dish; while two are necessary for ten or twelve. Moreover, one bottle of wine divides well in eight; if, therefore, the host desire to give with the roast one glass of particularly fine ripe Corton or Pomard, a single bottle is equal to the supply; and so with any other choice specimen of which a single circulation is required; and of course the rule holds equally if the circuit is to be repeated.

And this leads us to the question—and an important one it is—of the wine.—*Nineteenth Century*.

DRY-ROT IN TIMBER.*

NEARLY everybody has heard of dry-rot, and knows that it is something which causes the destruction of wood in a manner different from ordinary decay. Some suppose the effect to be due to peculiar insects that gnaw timber to powder, and others have no very definite notions as to what produces it. Carpenters, ship-builders, lumbermen, and house-owners often find, by the rapid destruction of their property, that, whatever its cause, it is a very serious matter, and they seek to be protected from the evil, though taking little pains to inform themselves of its real nature and conditions. The subject is, however, one of curious scientific interest, and has now come to be pretty well understood. An excellent work upon it has recently been compiled by Mr. T. A. Britton, an eminent British architect, who has ransacked all sources of information; and for the materials of the statements which here follow we are indebted to this book.

To understand the nature and effects of dry-rot we must first glance briefly at the structure and properties of wood. The mass of the trunks of timber-trees consists of slender, short fibers, with tapering ends, which overlap each other; but this overlapping does not prevent the passage of sap through them. At first these fibers are hollow, but are gradually filled by the deposition of solid matter from the sap within them. The strength of wood is due to the shortness and overlapping of the fibers, and to the presence of this deposit. Woody fiber pervades the tree from the tips of the roots to the extremities of the branches, and is the chief organ of circulation. A current of sap passes upward through it, from the roots to the leaves; and another

* A Treatise on Dry-Rot in Timber. By Thomas Allen Britton. London and New York: E. & F. N. Spon.

current, containing the products of leaf-action, passes back from the leaves, and is distributed for the uses of the tree. As wood grows older it grows darker, particularly in the center of the stem or heart. This darkening is due to the deposit within the fibers; and when a tree reaches maturity the fibers are so filled as no longer to join in the general circulation. Now, this inner or heart wood is less liable to decay than the outer or sap wood, and sap, as is well known, is the agent of destruction. Sap is water with sugary, saline, albuminous, mucilaginous, and gummy matters dissolved in it, and such solutions ferment easily and rapidly. Fermentation is a state of vegetable matter in which the various molecules, sugary, oily, albuminous, etc., exert their peculiar attractive and repulsive powers, forming new combinations, which at first change and at length destroy the texture of the substance of which they were formerly a part. Every one knows the smell of pure, fresh wood. If you bore into wood in which the sap has just begun to ferment, you get a vinous smell, which is soon followed by the smell of putrefactive decay, unless means are taken to arrest the chemical changes that are in progress. This decomposition of wood containing sap is ordinary rot or wet-rot. It is the most general and the most fatal cause of decay in wood; but it has attracted less attention than the more startling but less common evils of dry-rot, and the destruction of timber by insects.

The *seasoning* of wood, whether naturally or artificially, is simply the evaporation of its sap. Decay can not occur in well-seasoned wood if it is kept dry. It matters little whether wet is applied to timber before or after the erection of a building: it can not resist the effect of what must arise in either case; for heat and moisture will produce putrid fermentation. In basement stories with damp under them, dry timber is but little better than wet, for if it is dry it will soon be wet, and decay will only be delayed while the timber is absorbing moisture; and the amount it receives will depend upon the closeness of the deposit within its fibers. This moisture dissolves the substances held in solution by the sap, and fermentation begins, with its usual train of consequences.

Dry-rot is one of these consequences. Ordinary decay must have begun before dry-rot sets in. When the moisture in wood begins to ferment, whether it be the natural sap, or the water absorbed by seasoned timber, the conditions are ripe for the inroads of dry-rot, which can no more occur without moisture than wet-rot. The immediate agent of destruction, in this case, is of vegetable origin. It takes its name from the dust to which it reduces timber. That degree of moisture which is favorable both to natural decay and to the growth of plants is essential to the process of dry-rot. The vegetation that produces it belongs to the natural group of fungi. This group is made up of plants having distinct vegetative and reproductive systems, and their best known representative is the common mushroom. If you ex-

amine the mold on which this singular plant is seen to grow, you will find it penetrated with delicate, whitish, interlacing filaments which are the vegetative system of the plant. This part of a mushroom is called the *mycelium*, and from it arises the reproductive portion which grows above ground. But the only part of this above-ground portion that is essential, and that is found in all fungi whatever, is just that part which escapes ordinary observation. Everybody has seen the umbrella-like cap with the radiating vertical plates on its under surface. These plates are covered by a membrane which has the same office as the seed-vessel of the higher plants. It bears the minute reproductive bodies of the fungi, analogous to common seeds, and called spores.

The only parts of a mushroom which are common to all fungi are the mycelium or thready, interlacing portion which grows underground, and the minute, microscopic spores which are cellular in structure and so small that thousands of them are required to form a body the size of a pin's head. The fungi differ among themselves in many ways; but mycelia and spore production always occur in them, and are their essential characters. Every plant of which this mycelium forms a part, spreading its web throughout the substance on, or in, which it grows, belongs among fungi. Most of the species are either quite invisible, or else their parts are so small as to be indistinguishable. But some sort of reproductive organs exist, and spores are always produced. The mycelium is often so minute as to traverse living plants and the pores of solid wood. It grows rapidly and causes quick decay. Potato-rot, the yeast- and vinegar-plants, mildews, rusts, and smuts of grain, and molds of all kinds, are part of this immense group of plants that lives upon decay and fills the air with its countless myriads of spores. These subtile, germinal particles are lodged everywhere. They are light as vapor and abound in air, in water, in dust, in sand, ready, when warmth and moisture favor, to burst into life. As has been said, the dry-rot fungi flourish upon the products of wet-rot. Different stages of decay produce food of different qualities, adapted to different species of fungi. One species takes up the process where another leaves it, and carries it further and further forward.

Dry-rot may begin its ravages in the interior of timber as easily as upon the surface. As atmospheric dust is filled with the spores of fungi, they may be conveyed by rain into the earth, absorbed by the roots of vegetables, and diffused with the sap throughout the whole plant. There are numerous species of dry-rot fungi adapted to different conditions of life and presenting different aspects. Nor are they restricted to timber. They may flourish in the earth, where they present a perfectly white mycelium, branching and interlacing like roots; and when workmen are employed on grounds which are affected by the dry-rot fungi their health is often disturbed. A few years since, while a London builder was putting up some houses at Hampstead, his men were never well. He afterward learned that the ground was affected

by rot, and that, within one year after the house was erected, all the basement floor was in a state of premature decay. In cases of dry-rot, where the mycelium passes through substances from the external surface, it separates into innumerable small branches; when it proceeds from slime in the fissures of the earth, the mycelial fibers shoot in every direction and are very much tangled. Arising from the roots of trees, they look at first like hoar frost, but soon show regular toadstools. When they grow in very damp situations, they feel fleshy and extend equally around a circular space which they wholly cover unless obstacles interpose.

Excessive damp is unfavorable to this fungus, and its growth is more rapid in proportion as the situation is less damp, until the proper point for the growth of vegetation is reached. When the fungus extends to dry situations, its effects are more destructive to the timber on which it grows: it is very fibrous, and in part covered with a light-brown membrane perfectly soft and smooth. It is often of great magnitude, projecting from the timber in a white spongeous excrescence, on the surface of which a profuse humidity is frequently observed. Sometimes it forms only a fibrous, thin-coated, irregular web on the surface of the wood. Excrescences of a fungiform appearance are often protruded amid those already described, and are evidences of a very corrupt state at the spots whence they spring. Sometimes they arise in several fungiforms, each above the other, without any distinction of stem; and in some corrupt states the small acrid mushroom is generated.

But there are two or three species of fungi that are chiefly concerned with the process of dry-rot. The *Merulius lachrymans* (often called *the* dry-rot) is a most formidable enemy of timber. When the section of a piece of wood attacked internally by dry-rot is examined through a microscope, and minute white threads are seen interlaced and matted together all through its substance, and when this cottony texture effuses itself over the surface of the timber, and in the center of it a gelatinous substance forms which gradually becomes tawny and wrinkled and sheds a red powder on the white, downy surface, you have the *Merulius lachrymans*. But, long before this last stage of growth is reached, the interior of the wood has perished. As soon as the cottony filaments are seen upon timber internally affected, we may be sure that an apparently solid beam may be crumbled to dust between the fingers. In his botanical description of this plant, Dr. Greville says it is "soft, tender, at first very light, cottony, and white; veins appear, at length, which are of a fine orange or reddish brown, forming irregular folds, usually so arranged as to appear like pores, but never anything like tubes, *and, when perfect, distilling drops of water.*" Hence the term *lachrymans*. The folds or pores here spoken of are the reproductive portion of the plant. They are covered by the hymenium or spore-bearing membrane, which sheds its red powder

upon the white mycelium. In this fungus the stem is entirely absent, and the cap is attached by its back. In the different species we may find the reproductive or spore-bearing portion in the form of a cup, or a goblet, or a saucer; of an ear, a bird's nest, a horn, a bunch of coral, a button, a rosette, a lump of jelly, or a piece of velvet. The *Merulius* is found in cellars and hollow trees, sometimes several feet in width.

Another fungus, the *Polyporus hybridus*, is an especial enemy of oak-timber. It is described by Berkley as "white, mycelium thick, forming a dense membrane or creeping branched strings; hymenium breaking up into areæ, pores long, slender, minute." This species makes great havoc in the navy. At one time it is said, in the memoirs of Pepys, thirty new wooden ships in the British navy, "for want of proper care and attention, had toadstools growing in their holds as big as one's fists, and were so decayed that the planks dropped from their sides." In the beginning of this century, three 74-gun ships of the Royal Navy decayed in five years; three others in seven years; and a 100-gun ship in six years. Fungi have been seen growing between the timbers of a man-of-war strong enough to force a plank half an inch from the ship's side.

But, without attempting to discriminate among the fungi causing dry-rot, it may be stated generally that, in timber that has been only superficially seasoned, this disease often arises internally, and has been known to convert the entire substance of a beam, excepting an inch or two at the surface, into fine, white, and thread-like vegetation, which forms a thick, fungous coat at the ends of the beam, otherwise appearing perfectly sound. This has often been observed in large girders of yellow fir, which have seemed sound on the outside. Major Jones, R. E., states of a building in Malta, that "the timbers had every external appearance of being sound, but on being bored with an auger they were found internally in a total state of decay."

The first symptoms of dry-rot in timber are swelling, discoloration, moldiness, and a musty smell. As the disease advances the fibers shrink lengthwise and break, presenting many deep fissures across the wood; finally, the cohesion of the wood is utterly destroyed, and at the least disturbance it crumbles to powder. Before it has time to destroy the principal timbers in a house, it gets behind the skirtings, dadoes, and wainscotings, drawing in the edges of the boards, and splitting them both horizontally and vertically. When cleared of the fungus they look like wood that has been charred. Though affected but a short time, a slight pressure will break them asunder: and, when examined, the fibrous fungus will be seen closely attached to the decayed wood.

Timber that is floated down rivers and conveyed from place to place in ships is very liable to this disease. It is said of the exports of timber from Canada to England, that few cargoes in the log arrive

in which, in one part or other of almost every log, you will not see the beginning of this rot, either as reddish, discolored spots, which, when scratched by the nail, show that the texture to some little depth has been reduced to powder, or else the white fibers themselves may be seen growing. If the cargo was shipped dry, and had a rapid passage, the case is not so bad; but when shipped wet, and the voyage has been prolonged, white fibers will be seen growing over nearly every part of the surface of every log, especially if they are of yellow pine, red pine, and oak.

When *deal* (pine planks) is shipped wet in Canada, it is also covered with a network of white fibers on its arrival in England, and even when shipped tolerably dry the fungus will be found upon some of the pieces. When they have been floated down our rivers and shipped as soon as they were taken from the water, at the end of the voyage they are often so covered with this network of mycelial fibers that force is necessary to separate them, and they will grow together again in the barges before being landed. If deals in this state are piled flatwise, a whole pile will become deeply affected with rot in six months. In some instances the rot penetrates to the depth of one eighth of an inch. The decay may be arrested by sweeping the surface of each deal, and repiling them upon their edges during dry weather. The ships which carry this timber, though built of good, sound, well-seasoned oak, must be carefully dealt with, or they will become affected. It is usual to scrape their surface as soon as they are clear of the cargo, and sometimes the hold is washed with a desiccating fluid. The effects of dry-rot upon European deals are very similar to those exhibited by Canadian deals. Decay is more rapid in white deal than in yellow, for the white deal absorbs more water than yellow deal. In the same way yellow deal absorbs more water and decays faster than red deal.

An example of the rapid decay of timber from dry-rot was given by Sir Thomas Deane in 1849 before the Institution of Civil Engineers in Ireland. It occurred in the Church of the Holy Trinity at Cork. On opening the floors under the pews, a most extraordinary appearance presented itself. There were flat fungi of immense size and thickness, some so large as almost to occupy a space equal to the size of a pew, and from one to three inches thick. In other places fungi appeared growing with the ordinary dry-rot, some of an unusual shape, in form like a convolvulus, with stems from a quarter to half an inch in diameter. When first exposed the whole was of a beautiful buff color, and emitted the usual smell of the dry-rot fungus.

During a part of the time occupied in the repairs of the church the weather was very rainy. The arches of the vaults having been turned before the roof was slated, the rain-water saturated the partly decayed oak beams. The flooring and joists, composed of fresh timber, were laid on the vaulting before it was dry, coming in contact at the same time with the old oak timber, which was abundantly supplied

with the seeds of decay, stimulated by moisture, the bad atmosphere of an ill-contrived burial-place, and afterward by heat from the stoves constantly in use. All these circumstances account satisfactorily for the extraordinary and rapid growth of the fungi.

The decayed state of a barn-floor attacked by rot is thus described by Mr. B. Johnson: "An oak barn-floor which had been laid twelve years began to shake upon the joists, and on examination was found to be quite rotten in various parts. The planks, two and a half inches in thickness, were nearly eaten through, except the outsides, which were glossy and without blemish. The rotten wood was partly in a state of snuff-colored, impalpable powder; other parts were black, and the rest clearly fungus. No earth was near the wood."

An indication of dry-rot in a damp pantry will be a coating of fine powder, like brick-dust, upon the shelves and earthenware, which consists of myriads of reddish spores shed by the dry-rot fungus. When these spores fall upon a wet surface, the red skin cracks at both ends, and fine filaments are sent out, which grow and ramify in all directions, and do their work of mischief with the timber of the closet.

Ventilation as a remedy for dry-rot in buildings is of doubtful service. If dry air be admitted in such a way as to absorb the moisture which sustains it, the fungus will of course be destroyed; but the trouble is that the circulating air will carry the spores along with it, and so spread the disease to unaffected parts. This is the great danger with dry-rot, while the wet-rot or ordinary decay is only communicated by actual contact. Another difficulty in ventilating for dry-rot arises from the fact that air, in passing through damp places, soon becomes humid, and loses its efficacy, or even does more harm than good. Intestinal decay is not reached by ventilation, for the air can not penetrate the spongeous exterior rottenness of timber so affected.

The temperature at which dry-rot proceeds most rapidly is 80° Fahr. At 90° it is slower, and at 100° slower still, and from 110° to 120° is generally arrested. Its progress is rapid at 50°, slow at 36°, and is arrested at 32°; but will return if the temperature is again raised to 50°. But in a constancy and equality of temperature timber will endure for ages. The wooden piles on which Venice and Amsterdam are founded remain sound because of the constancy of the conditions that surround them. Nothing is more destructive to wood than partial wetting. If it be kept always wet or always dry, and at a steady temperature, decay does not begin. It is recorded that a pile was drawn up sound from a bridge on the Danube that parted the Austrian and Turkish dominions, which had been under water fifteen hundred years. It has been remarked that the part of a ship which is constantly washed by bilge-water is never affected by dry-rot; and that the planking of a ship's bottom which is next the water remains sound for a long time, even when the inside is quite rotten.

As the decay of wood is chiefly due to the presence in it of sap, and

as dry-rot can only thrive upon decaying timber, it is apparent that the best protection against both these evils is careful seasoning. When wood dries gradually in the air by the process of natural seasoning, it should be placed in a dry yard and sheltered from sun and wind. This method may be recommended for specimens of moderate thickness; and the time needed is two years for timber used in carpentry, which in this period loses one fifth of its weight. Four years are needed for timber that is to be used in joinery, in which time it will lose one third of its weight. It is important that timber be reduced to its proper size for use before seasoning; for, however dry it may become, when it is cut smaller it will shrink and lose weight. At first the seasoning should proceed slowly, and the pores upon the surface should remain open to permit the free evaporation of internal moisture. It should be set on bearers to admit a circulation of air all around it. The sleepers at the bottom of the pile should be perfectly level and solid; for timber bent in seasoning will retain the same form when dried. The time required for drying under cover is shorter than in the open air in the proportion of five to seven. Three years are required to season ship-timber; the timbers are shaped a year before they are formed, and then left a year in a skeleton shape to complete the seasoning.

Sappy timber that must be seasoned quickly, in cases where strength is not chiefly required, should be immersed in running water as soon as felled. It should be chained down beneath the surface, as partial immersion is very destructive. Boards placed end on at the head of a mill-race for two or three weeks, and then set upright in the air, and turned daily, are said to floor better than timber that has been years in dry seasoning. The longer wood has been under water the faster it dries. The process of water-seasoning is easily explained. Sap is denser than pure water, and it is inclosed in membrane. By osmotic action pure water takes the place of the sap and so renders the wood less liable to ferment. Again, pure water evaporates more readily than water which contains certain principles in solution, and hence water-soaked timber dries more rapidly. Timber steeped in water has some of its substance dissolved thereby. Boiling and steaming are said to prevent dry-rot by getting rid of spores and coagulating albumen.

GENERIC IMAGES.

By FRANCIS GALTON, F. R. S.

IN the prescientific stage of every branch of knowledge, the prevalent notions of phenomena are mainly founded on general impressions. But when that stage is passed, and the phenomena are submitted to measurement and numbering, very many of the notions

that were derived from general impressions are discovered to be wrong, even absurdly so. I do not speak only of such matters as astrology and alchemy, but of those also with which most persons are acquainted. Think of the nonsense spoken every day about signs of coming weather, in connection, for example, with the phases of the moon, and firmly believed in by many respectable people. Think of the ideas about chance, held by those who are unacquainted with the theory of probabilities. Think of the notions entertained on heredity before the days of Darwin. Think of the ridiculous nostrums that have been prescribed for common ailments by gifted and experienced practitioners, the merits of which have been also vaunted by the invalids who tried them. It is not necessary to go into more detail in illustration of the fallacies of popular generalizations. The list of them is endless; they are to be abundantly found, as already observed, in every branch of knowledge, before it has been seized in the firm and sure grasp of processes that depend upon exact measurement and number. That popular notions are habitually incorrect may be taken for granted, and my purpose in this memoir is to explain one cause of their incorrectness.

I propose to call attention to an error in the operations of the mind, whenever it blends memories together, and to show why the brain is a faulty apparatus for elaborating general impressions. I shall argue that we have no means of correcting its necessarily fallacious results, except by picking them to pieces, and going back to the facts whence the general impressions were derived, and by dealing with those facts on true statistical principles. Thus if we hear that some medical nostrum is highly reputed, or that some particular appearance is an excellent prognostic of coming weather, our first step toward investigating the truth is not to ask whether the belief is firmly held, or of old standing, or shared by many, but to obtain a considerable number of instances and to set off the failures against the successes.

The general impressions and ideas to which I refer guide the great majority of our every-day actions. We have a general impression that the day looks rainy, and we take an umbrella. We find ourselves in a railway-carriage with a person who looks sociably inclined and agreeable, and we accost him accordingly.

In an infinity of cases like these, the opinion on which we act has not been formed by any process of reasoning; neither has it been made by considering what similar experiences we have had, and counting their results on this side and on that, but it is the effect of blending together a large number of similar incidents. These blended memories are the subject of my present memoir. I shall try to prove that blended memories are strictly analogous to blended pictures, of which I have produced many specimens by combining actual portraits together; and I shall explain the peculiarities of the images by those of the portraits; then I shall show that the brain is incompetent to blend images in their right proportions. My conclusion will be that our unreasoned impres-

sions are of necessity fertile sources of superstition and fallacy from which the child and the savage are never free, and with which all branches of knowledge are largely tainted in their prescientific stage. Lastly, that it is only by the strict methods of scientific inquiry, namely, by measurement and number, that these fallacies can be cleared away and the truth discovered.

The physiological aspect of simple and blended memories is intelligible enough in its broad outlines, and may be briefly described. Whenever any group of brain elements has been excited through an impression of one of the senses, it becomes, so to speak, tender and liable to become again excited, under the influence of other kinds of stimuli. Whatever may be the cause of any new excitation, the result of its reproduction is to create an imaginary sense-impression, similar to that by which the first excitation had been caused; and this we call memory. Blended memories must necessarily follow the excitation of many associated groups of brain elements, under the influence of a stimulus that sets them simultaneously in action.

Faint memories are particularly apt to blend together, and they often defy analysis afterward. We are shown some picture of mountain and lake, from a county we have never visited, yet it seems familiar to us; it accords with what we have seen dozens of times in Scotland or Switzerland or elsewhere, but our memories are confused and obscure, and we can not wholly disentangle the incidents to which they relate.

Memories that are extremely vivid may at the same time be very mobile, and capable of blending together. Much instruction on these matters can be derived from those who possess the power of what is called the visualizing faculty, in a high degree. The objects of their memory are conspicuous images; they can retain them for a long time before the eye of their mind, they can dismiss or change them at will, and they can, if they please, subject them to careful examination from every side. I do not know any faculty that varies so much as this in different persons. None can vary more, because its range lies between perfection and nothingness. It is sometimes absolutely deficient, for there are persons who never see mental images even in dreams, and there are others who are said to have lost the power of seeing them. I need not speak of cases where the visualizing power is feeble, as they are common. Many are like those to whom St. James alludes when he speaks of "a man beholding his natural face in a glass, who beholdeth himself and goeth his way, and straightway forgetteth what manner of man he was." It will be more to my point to show how perfect the visualizing faculty sometimes is, at the same time that the images may be moved with the utmost facility in the field of the mind's eye, which is a first step toward their blending together. Out of the many available instances I will only quote one, and will choose that one chiefly because it has recently excited some public attention. There

appeared in the "Spectator," of December 28th last, two very interesting letters concerning a peculiar form of visualizing possessed by the late Mr. Bidder, the engineer, known in early life as the "calculating boy," and this gift is possessed in a high though less degree by several of his descendants. Thus the eldest son, Mr. George Bidder, Q. C., can mentally multiply fifteen figures by fifteen, though not with the same precision and rapidity as his father. One of the two letters is from Mr. Bidder's friend, Professor Elliot, who writes thus:

> If he saw or heard a number, it seemed permanently photographed in his brain. In like manner he could study a complicated diagram without seeing it, when walking and apparently listening to a friend talking to him on some other subject. The diagram stood before him in all its lines and letters.

The second letter is from Mr. George Bidder, who writes:

> His memory was of a peculiar cast, in which figures seemed to stereotype themselves without an effort . . . . (accompanied) by an almost inconceivable rapidity of operation. I speak with some confidence on the former of these faculties, as I possess it to a considerable extent myself (though not to compare with my father). Professor Elliot says he always saw mental pictures of figures and geometrical diagrams. I always do. If I perform a sum mentally, it always proceeds in a visible form in my mind; indeed, I can conceive no other way possible of doing mental arithmetic.

Mr. Bidder continues, in a letter addressed to myself:

> If my mind is engaged solving a geometrical problem including the relations of lines, plans, etc., I *deliberately* build up in my mind a figure, plane or solid, as the case requires; but there is a limit to my power in this respect, e. g., if the problem includes the relative positions and intersections of many surfaces, it becomes a painful effort to grasp them all simultaneously.

All this shows that mental impressions of extreme vividness may at the same time have great mobility and be subject to "an almost inconceivable rapidity of operation," and that they need not be fixed in the way that hallucinations often are.

Next as regards actual blending. Mr. G. Bidder, in very kindly replying to some questions that I put, writes:

> Nothing is easier than to imagine, and to watch mentally, the rotation of anything to which such motion is natural, e. g., a wheel, a crank, etc. In many such cases I incline to think the process consists in calling up a sort of typical image formed out of innumerable bygone experiences.

This was Mr. Bidder's own view, quite independent of any suggestions from myself, and is therefore all the more valuable.

The strongest proof that those who have vivid memories of special objects are also capable of blending them is found in the works of such men as Macaulay. I am assured on excellent authority that his visual memory of book, page, and line was of the clearest possible char-

acter; it was described to me as having been "spectral" in its perfect definition. Yet no one better than Macaulay had the power of vivid generalization, that is, of creating a single clear image out of a multitude of allied facts. Many poets and painters have had the visualizing faculty in an extraordinary degree, while it is in the brains of poets and painters generally that we find the artistic power to reside of producing pictures that are not copies of any individual, but represent the characteristics of large classes. Painters and poets create blended portraits in profusion, and we, who are not gifted as they are, can nevertheless understand and appreciate their works. In other words, their blended images are well-defined representations of what we ourselves had already conceived in a dim and confused way.

There seems, then, to be no doubt, from whatever side we may approach the subject of memory—whether from its material or its mental aspect, and, in the latter case, whether the visualizing faculty be faint or vivid—that different special memories admit with facility of being blended into a common image. From blended memories to general impressions and ideas is a step on which we need not linger, the latter being derived from the former. They are faint traces of them, and they inherit all their errors.

I conclude, then, that the formation of blended images is an habitual operation of the mind, whence those general impressions have arisen by which the great majority of our daily actions are guided.

I will now proceed to speak of blended portraits, in order to illustrate the formation of blended memories and the effect of the resultant images; or let me henceforth describe them as generic portraits and generic mental images. The word generic presupposes a genus. The objects to be portrayed must all have many points of likeness in common, and it is of especial importance that characteristics of a medium quality should be much more common among them than those that deviate widely. No statistician dreams of grouping heterogeneous facts in the same table; no more do I propose to group heterogeneous forms in the same picture. Statistical averages, and the like, are nonsensical productions unless they apply to objects that cluster toward a common center; and composite pictures are equally monstrous or meaningless unless they are compounded of objects that have a common similarity to a central ideal type.

It might be thought that blended portraits would form mere smudges, and so they would if only a few specimens of extremely different casts of features were combined, but in all groups that may be called generic the common points of resemblance are so numerous, and medium characteristics are so much the more frequent, that they predominate in the result. All that is common to the group remains; all that is individual disappears.

Generic portraits are made by a method which I described for the

first time last year, under the title of composite portraiture. I showed that it was possible in many ways to combine two or more portraits into a single one, if they are of the same size and taken in the same attitude. I have produced the combination by various optical means, such as the convergence of images from different magic lanterns upon the same screen, and by a small apparatus which is, in fact, six cameras in combination, in which six different images may be simultaneously viewed, and afterward thrown upon the same photographic plate. In addition to these is the plan I originally employed, of throwing carefully adjusted images of different portraits in succession upon the same portion of the same sensitized photographic plate. It is by the latter process that blended memories are illustrated. In all these methods the general result is substantially the same, subject only to such discrepancy as will always exist between a photograph and the image from which it is made. A composite portrait is in all cases produced, in which the whole of the components coexist. It is surprising with what excellent effect we can combine the features of persons who are not too dissimilar in their general appearance. We obtain from them a composite portrait that is identical with no one of the components, but which comprises all, each having its own fractional share in the total effect. I have made several composites from medals of historical personages; such as from different coins bearing the effigy of Alexander the Great, none of which are closely alike. Thus I have brought out the common features of all of them and produced what is presumably a nearer approach to the ancient ideal type than has ever previously existed. I am much indebted to the kindness of Mr. R. Stuart Poole, the learned curator of the magnificent collection of medals and gems in the British Museum, for having selected the best and most suitable specimens, and having procured plaster casts of them for me, whence my photographs were made. The portraits on coins are very convenient for composites, as they are pure profiles. I have also various criminal types, composed from the photographs of men convicted of heinous crimes. They are instructive as showing the type of face that is apt to accompany criminal tendencies, *before* (if I may be allowed the expression) the features have become brutalized by crime. The brands of Cain are varied; therefore the special expressions of different criminals do not reënforce one another in the composite, but disappear. What remain are types of faces on which some one of the many brands of Cain is frequently destined to be set. I am particularly struck by three of these types that were each deduced from six or seven components; two of the groups are of men convicted of manslaughter and crimes of violence, the other of habitual thieves. These three composites are as alike as brothers; the compound composite gives a low class of face, but not one, I think, that most persons would associate with especial villainy. I have also two other composites very like these three, and I find that,

whenever I put any three of the five together, I arrive at very nearly the same typical face.*

The process is one of pictorial statistics, suitable to give us generic pictures of man, such as Quetelet obtained in outline by the ordinary numerical methods of statistics, as described in his work on "Anthropométrie." He procured the measurements of the limbs of a large number of person of both sexes and of various ages, and of the distances between such points on the surface of the body as are sufficiently defined to measure from. From these numerical data he calculated and laid down upon paper the average positions of those points, and therefrom constructed sketches of the typical man at various periods of his growth, like Flaxman's drawings or Retsch's outlines. By the process of composites we obtain a picture and not a mere outline. It is blurred, something like a damp sketch, and the breadth of the blur measures the variability of individuals from the central typical form.

It may be objected that the contribution from each portrait, when there is a multitude of them, is so small that, in the great majority of cases, it might perhaps leave no trace at all in the generic portrait, or, at all events, on the photograph; consequently, that the result may not be what it professes, but is, perhaps, due to a comparatively small portion of the components, in which the lights and shades happen to be sufficiently marked to create a decided impression. I therefore tried a simple experiment, which leaves no doubt that this objection is unfounded under even very exceptional circumstances, so far as the photographs are concerned, and, therefore, *a fortiori*, as regards composite results by purely optical means. I contrived a small apparatus to be held in one hand. It had a receptacle behind for sensitized paper, in front of which was a hole closed by a shutter, that sprang back when I pressed my finger on a catch, and closed at the moment that I released the pressure. In the other hand I held a chronograph, in which the hand that marked quarter-seconds began to travel the instant I pressed a catch, and stopped when I released it. I worked these two instruments simultaneously, holding one in each hand. The chronograph readings gave me the sum of the successive short periods of exposure of the sensitized paper, and I could watch the length of each of them. Thus provided, I made several experiments, and can testify to the identity of the tint made by one thousand short exposures with that made by a single exposure of the same length of time as all the thousand put together. What differences there were, lay well within the limits of error in experimenting.

Composite portraits are, therefore, much more than averages, because they include the features of every individual of whom they are composed. They are the pictorial equivalents of those elaborate sta-

* I exhibited many photographic composites at the Royal Institution on the 25th of April. Some were transparencies thrown upon a screen, others were made before the audience by converging magic lanterns.

tistical tables out of which averages are deduced. There can not be a more perfect example than they afford, of what the metaphysicians mean by generalizations, when the objects generalized are objects of vision, and when they belong to the same typical group, one important characteristic of which is that medium characteristics should be far more frequent than divergent ones. It is strange to notice how commonly this conception has been overlooked by metaphysicians, and how positive are their statements that generalizations are impossible, and that the very idea of them is absurd. I will quote the lucid writing of Sir W. Hamilton to this effect, where he epitomizes the opinions of other leading metaphysicians. I do so the more readily because I fully concede that there is perfect truth in what he says, when the objects to be generalized are not what a cautious statistician would understand by the word generic.

Sir W. Hamilton says: *

> Take, for example, the term *man*. Here we can call up no notion, no idea, corresponding to the universality of the class, or term. This is manifestly impossible. For as *man* involves contradictory attributes and as contradictions can not exist in one representation, an idea or notion adequate to *man* can not be realized in thought. The class *man* includes individuals, male and female, white and black and copper-colored, tall and short, fat and thin, straight and crooked, whole and mutilated, etc., and the notion of the class must therefore at once represent all and none of these. It is therefore evident, though the absurdity was maintained by Locke, that we can not accomplish this; and, this being impossible, we can not represent to ourselves the class *man* by any equivalent notion, or idea. All that we can do is to call up some individual image and consider it as representing, though inadequately representing, the generality. This we can easily do, for as we can call into imagination any individual, so we can make that individual image stand for any or for every other which it resembles, in those essential points which constitute the identity of the class. This opinion, which, after Hobbes, has been in this country maintained among others by Berkeley, Hume, Adam Smith, Campbell, and Stewart, appears to me not only true but self-evident.

If Sir W. Hamilton could have seen and examined these composite portraits, and had borne in mind the well-known elements of statistical science, he would certainly have written very differently. No doubt, if what we are supposed to mean by the word *man* is to include women and children and is to relate only to their external features and measurements, then the subject is not suitable for a generic picture, other than of a very blurred kind, such as a child might daub with a paint-brush. If, however, we take any one of the principal races of man and confine our portraiture to adult males, or adult females, or to children whose ages lie between moderate limits, we ought to produce a good generic representation.

It will, I trust, be quite understood that, although for the sake of

* "Lectures," ii., 297.

brevity I chiefly confine my remarks to visual representations, they are intended to apply equally to all the senses.

A generic image appears to be nothing more than a generic portrait stamped on the brain by the successive impressions made by its component images. Professor Huxley, from whom I have borrowed the apt phrase, has expressed himself to a similar effect in his recent "Life of Hume," page 95. I am rejoiced to find that from a strictly physiological side this explanation is considered to be the true one, by so high an authority, and that he has, quite independently of myself, adopted a view which I also entertained, and had hinted at in my first description of composite portraiture, though there was not occasion at that time to write more explicitly about it.

When I am adjusting portraits to make a composite, and at the moment when the adjustment is being effected, I always experience a quick sense of satisfaction curiously analogous to that which is felt on the first recognition of a doubtful likeness of any kind. I have the same disagreeable feeling of the existence of a puzzle which I can not make out, accompanied by the conviction that the puzzle is on the point of being solved. In the next instant coalescence takes place between what is seen and what was recollected. I am as sure as it is possible to be on such grounds as these, that the analogy between catching the coincidence of two similar portraits when optically superposed and that of the coincidence of a visible object with a past impression or with a preëxistent general idea is true and not metaphorical only.

It is very instructive to note the first appearance of a generic image, and to watch the way in which the mind carves images out of the medley of its available material. It can not grasp an image of any complexity unless the elements of which it consists form a congruous composition, that is to say, one whose parts are connected by such easy lines of association that the mind runs rapidly over the whole of it, and takes it all in by what seems to be a single glance. Generic images begin, at least according to my own experience, by being exceedingly imperfect and vague because they are very comprehensive. Then limitations commence, each of which is the cause of a more distinct picture being formed, and so the mind runs first through genera, then through species, continually seeking more congruity and clearer definition, but at each step with a loss of comprehensiveness. If allowed to do so, it descends to individuals. Let us, as an example, call up a generic image of a clergyman preaching. I first see a pulpit of somewhat undefined height; with a vague figure in it. This figure becomes white, in a surplice; a competing figure in a black ground temporarily yielding place. Then I see various accessories suitable to the surplice, such as Gothic architecture, ritualistic decorations, and the like. After this the interiors of particular churches begin to present themselves, but, as I wish to confine my

thoughts to generalities, I refuse to dwell upon single cases. While waiting for some new general idea to suggest itself, I have the consciousness of there being many competing images struggling to appear, which do not belong to the same genus, and therefore restrain instead of reënforcing one another. At length the black-robed figure suddenly reappears; on viewing which, the accessories assume an appropriate character, and the mind wanders among a variety of these, as it had previously done among the others. In the course of the degradation of highly generalized pictures to individual ones, many generic representations are sure to appear which are good so far as they go, but are not complete pictures. Whenever the mind has halted in a vain effort to make the image more comprehensive without injuring its congruity, the dead-lock is relieved by the sudden obliteration of a large part of it, leaving a vacancy which is filled by some one of the competing associations overcoming the others, and presenting itself within the narrow field of view of our full consciousness and attention.

Other conditions being the same, it is reasonable to suppose that the idea that has been most frequently dwelt upon will have left the deepest impression on the brain, and will have precedence. Thus, in making a drawing of a pendulum in the act of swinging, we should always represent it at one or other side of its excursion, when it delays, stops for an instant, and returns. We see it longer in either of those extreme positions than in any of the intermediate ones. Similarly, we draw a man walking, or otherwise in motion, in the attitude where there is a momentary change of direction, and consequently more or less of rest at or about that position. It is different when the movement is continuous; the wheel of a moving carriage is drawn in a blur, with, however, numerous radial streaks, showing, if I mistake not, that attentive observation is never continuous, but acts in rapid pulses, so that the revolving wheel is seen in many momentary positions. I have endeavored, in this way, to measure the intervals between the successive throbs of close attention. If a wheel revolves rapidly, it is impossible to analyze its motion, and its spokes form an apparently equable shade.

In my memoir, read about a year ago before the Anthropological Institute, on composite portraits, I used a phrase, which I wrote with a little misgiving, which I have since quoted, and which I wish now to amend. I desired briefly to convey the idea that composite portraits were in a true sense generalizations and analogous to the images stamped on the brain, as already described, and I used these words: "A composite portrait represents the picture that could rise before the mind's eye of an individual who had the gift of pictorial imagination in an exalted degree."

The question we have now to answer is this:

If a person gifted with the visualizing power in perfection should pose his eye in the place of the object-glass of the camera, would the

generic image in his brain be identical with the photographic composite? (I am assuming, for argument's sake, that the photograph gives a true rendering of any optical image, which, in strictness, it does not.) Suppose a succession of many different pictures are to be displayed, each for the same brief period, and if a single other picture is displayed fifty times in succession, or for fifty times as long, would its share in the generic image be fifty times as large as that of any of the others, or, if not, what would its share be?

The reply is, that both in the photographic composite and in the processes of numerical statistics, its effect would be exactly fifty times as great, but in mental imagery this would certainly not be the case, and therein lies a fertile source of error in our general impressions. I have made some experiments on the subject, which are not as yet sufficiently advanced to be worth recording, but I may say that at present I see nothing in the results incompatible with the very reasonable supposition that the relation between the varying periods of exposure and the strength of the corresponding mental impression follows the law of Weber. This law is founded in the fact that, the more highly our senses are stimulated, the more is their discriminative power blunted. Thus a double number of candles does not double the apparent illumination; it only increases it by a certain amount, which is always the same, whether the light of a single candle be added to that of another single candle, or the light of a thousand candles be added to that of another thousand candles. The law is true of all the senses. The difference of noise made by dropping one shilling or two shillings on a table is not always distinguished by the ear, neither is that of discharging one or two thirty-eight-ton guns from the turret of the same iron-clad ship, as was shown in evidence concerning the recent frightful accident on board the Thunderer. That is to say, the same increment of noise may be produced by the fall of a shilling on a table, in the one case, as by a thirty-eight-ton gun in the other.

Let me take the present opportunity of saying that one effect of Weber's law is that a true composite never appears true, and is never what our uncorrected senses teach us to expect. If we mix a very dark gray with a very light gray, we might on first thoughts expect that their mixture would appear to be a medium gray, but Weber's law tells us that the eye judges differently, and we find, in trying the experiment, that the mixture is brighter than we had expected.* Of

* Weber's law may be well illustrated by placing in a row, say, five cards, painted quite black, each the size of half a sheet of note-paper. Then taking a whole sheet of white note-paper, tear it in half and lay one half on card 5 so as to cover it entirely. Tear the remaining half exactly across its middle and lay one half upon card 4; again tear the remainder in half and lay one half on card 3. Proceed similarly up to card 1; the fragment that remains is not wanted. Cut these papers into shreds (excepting No. 5, which can be left as it is), and distribute the shreds as evenly as possible over their respective cards. Then 1 will have one portion of white, 2 will have two portions, 3 will have four portions, 4 will have eight, and 5, which is wholly covered with white, will have

course, we could learn by much practice to correct the judgment of our senses, but it is only in rare and special cases that we have the necessary practice. I have often noticed my own ludicrous failures in estimating the relative depths of two parts of the same pool by the relative obscurity of the bottom. Maps of ocean-depths are never made on what may be called natural scales, but always on symbolic ones, in which consecutive increases of tint, as judged by the eye, correspond to successive increases of depth. According to Weber's law (which I content myself here with expressing in its original and approximative form), if it requires a tenfold period of exposure to make a doubly deep impression on the mind, it would require a hundred-fold period to make a trebly deep one, a thousand-fold period to make it quadruply deep, and so on. The one series follows an arithmetical, the other a geometrical progression.

Whatever the true law may be that connects the strength of the impression with the time that the object is before our eyes, or with the frequency with which it is seen, its form is certainly not very dissimilar to that of the law of Weber. Otherwise it would not accord with the fact that sights on which we have not lingered, often leave abiding impressions, while the pictures that hang on our walls, before our eyes, every day of our life, are not always remembered with vivid distinctness. The effect of the law, whatever its precise form may be, is to prevent generic images from having the same definition and simplicity as the corresponding photographs. The most extreme elements will always leave their traces very visibly because the medium elements are not present in sufficient number to overpower them. These images can not be otherwise than blurred and surrounded by monstrous and faint imagery. The attention is unable to deal with such pictures, because when it is engaged on one part of them the remainder slips out of memory. All parts of an image must be congruous and well defined before the attention can sweep so swiftly over the entire field of view as practically to bring it all at once into sight. If an image is incongruous and vague, the mind follows the course already described when the illustration was used of a clergyman in a pulpit.

The conclusions to be drawn from what I have said are that composite portraits are perfectly trustworthy when made by optical means and with proper precautions, and that photographic composites are as correct representations of these as photographs ever are of the pictures from which they are taken. Composite portraits are therefore to be considered as pictorial statistics. Also it is conceivable that general

sixteen. The effect of the scattered white on the cards is to produce various grays which the eye will judge to be separated by equal intervals of tint. Card 4, which contains eight portions, has the medium amount of white (eight and a half is the precise medium), but the eye reckons differently; it places the medium tint at card 3, which contains only four portions of white.

mental images should sometimes closely resemble these portraits except in one important respect; namely, that the effect produced by the huge bulk of ordinary facts is never in proportion to their numbers. Consequently, we find that undue consideration is inevitably given in generic images to all exceptional cases. When the exceptions in excess are balanced by those in deficiency, the value of the average will not be affected, and there is always a tendency toward that result. The fault that remains wholly uncorrected is, that the great prevalence of mediocre instances is overlooked, and the number and importance of the deviations are largely over-estimated. The tendency of the mind of the child and of the savage, and in all branches of knowledge in their prescientific stage, is necessarily toward the marvelous and the miraculous.

The generic images that might arise in a mind superhumanly logical and active would be subject to no other error than this, but in the human mind it is not so. Some of the images in every presumed generic group are sure to be aliens to the genus and to have become associated to the rest by superficial and fallacious resemblances, such as common minds are especially attentive to. Again, the number of pictures that are blended together is sure to fall far short of the whole store that would be available if the memory were immeasurably stronger than it is, and more ready in its action. Knowing also as I do, from considerable experience of composites, what monstrous and abortive productions may result from ill-sorted combinations of portraits, and how much care in selection and nicety of adjustment is required to produce the truest possible generic image, I cease to wonder at the numerous shortcomings in our generalizations and at their absurd and frequent fallacies. The human mind is a most imperfect apparatus for the elaboration of true general ideas. Compared with the mind of brutes, its powers are marvelous; but for all that they fall vastly short of perfection. The criterion of a perfect mind would be the power of always creating vivid images of a truly generic kind, deduced from the whole range of its past experiences.

General impressions are the faint traces left by generic images, and have all their defects, as well as others, due to their own want of definition. They are never to be trusted. Unfortunately, when general impressions are of long standing they become fixed rules of life, and assume a prescriptive right not to be questioned. Consequently, those who are not accustomed to original inquiry entertain a hatred and horror of statistics. They can not endure the notion of submitting their sacred general impressions to cold-blooded verification. But it is the triumph of scientific men to rise superior to such superstitions, to devise tests by which the value of beliefs may be ascertained, and to feel sufficiently masters of themselves to discard contemptuously whatever may be found untrue.—*Nineteenth Century.*

MONARCHY AND ITS DRAWBACKS.

VERY nearly a century and a half ago David Hume observed, with an air of surprise, that no form of government had proved so susceptible of improvement as monarchical government. "It may now," he writes, "be affirmed of civilized monarchies what was formerly said of republics alone, that they are a government of laws, not of men." There was only one constitutional monarchy in Hume's day—that of Great Britain, which he did not particularly love; and the only existing republics were strict aristocracies, such as the Venetian Republic and the Swiss Cantons. Hume was avowedly taking into account, not only such countries as France and Spain, but the little despotisms of Italy and Germany. "There are, perhaps, and have been for two centuries, near two hundred absolute princes, great and small, in Europe; and, allowing twenty years to each reign, we may suppose that there have been on the whole two thousand monarchs or tyrants, as the Greeks would have called them; yet of these there has not been one, not even Philip II. of Spain, so bad as Tiberius, Caligula, Nero, Domitian, who were four in twelve among the Roman Emperors." Since then the world has seen two great examples of that republican government which Hume assumes without question to be abstractedly the best—the Republic of the United States and the first French Republic; and assuredly the result has been considerable disenchantment. Nobody would nowadays deny that monarchy has proved capable of yet greater improvement than even Hume thought possible; and only a small minority of men, and those certainly not consisting of deep political thinkers, is persuaded that a country gains very much by exchanging an hereditary for an elective Chief Magistrate.

But of course a monarchy implies a dynasty; and dynasties are always raising a number of questions so perplexing that they are a considerable drawback on the value of monarchical government. In the first place, there is no subject on which men as a fact have fought and still fight so much. This country was for a hundred years at war with France on a question of the kind; and the war which it has just successfully concluded with Afghanistan sprang in great part from the same cause, since it was a doubt whether the Prince could nominate his own successor which primarily threw Shere Ali into the arms of the Russians. These questions of succession mix themselves up with the entire politics of countries in which there is no open strife about them. The position of the British monarchy and the view taken of it are strongly influenced by the double fact that our line of kings came in with a defective title, but that these defects have been practically removed by the course of circumstances and by time. The relation, again, of the Count de Chambord to his far-away cousins of

the Orleans branch deeply affects all French politics; and the untimely death of the Prince Imperial is a still more important factor in them.

Mr. Huxley, criticising these speculations of Hume in his recent volume, expresses the opinion that monarchies in our day are less likely to fall into discredit through inherent drawbacks or through the competition of republics than through their "tendency to become slightly absurd." The maintenance of kingship is undoubtedly dependent in great part on the majesty of kings; but this majesty is preserved with increasing difficulty. The purple robe has not only become frayed, but the wearer is sometimes under a strong temptation to exchange it for a dressing-gown. It is hard to say what is the safest general behavior for a royal personage. If monarchy retires into seclusion, people nowadays ask what is the good of it, and grumble at its costliness. If it associates itself with the tastes which are conventionally regarded as most respectable, by cultivating art, science, or letters, it incurs the repugnance of the multitude to whom these tastes are a symbol of pedantry or effeminacy. If, on the other hand, it simply enjoys itself, it becomes the prey of that overdone morality which is always affected by the dealers in malignant gossip. No doubt the Prince who died the other day in Paris was a good example of the class of idiosyncrasy which endangers monarchy. There was nothing remarkable about him save his exceptional rank and the historical dignity of his name. The type is perfectly well known—that of the foreign prodigal who wastes his substance in the city in which pleasure has become a business; and not simply a business, but a business conducted on the strictest commercial principles. But, if the heirs-apparent of thrones were often seen in the circles frequented by the last Prince of Orange, there would be a rapid decline of that kingly majesty which when it wholly disappears leaves (as Mr. Huxley justly says) little but absurdity behind it. The question between monarchies and republics would then be reduced to a simple question of their respective convenience; and, in countries governed as ours is, the question of convenience is very likely to end in turning on a mere calculation of cheapness or cost.

It is plain from Hume's language that the commonplaces of his day were all in favor of republics. There is in fact hardly a single writer of the time who does not praise them, though they all assume that a superhuman amount of diffused public virtue is necessary for their conduct. As we before said, the only known republics were petty or anomalous oligarchies; and the eulogies in fashion were in reality taken from classical panegyrics on Greek and Roman republics, profoundly misunderstood. There are countries which have severely suffered from this enthusiasm founded on ignorance. France owes to it the most fearful as well as the most absurd of her experiences during the first Revolution, and she is hardly free even now from some of

its evil effects. The over-estimate of the republican form of government based on classical commonplace has, among other things, prevented our knowing what may be said for or against its establishment in the older parts of the world. French republics have up to this time chiefly failed because too much was expected from them. If we look to facts for our guidance, we have few to rely upon except those furnished by the comparatively short history of the group of States making up the American Union. Now, the spectacle of the United States suggests not that a republican government is what it was deemed to be by most Englishmen in 1793, but that it is a government hardly worth the trouble of adopting in 1879. It is neither a Utopia of bliss nor a den of assassins and thieves, but simply a set of institutions like another, with advantages and drawbacks keeping the scales nearly evenly poised. The attractions which it had for thinkers of the once famous Utilitarian school plainly arose from miscalculation. They argued that the interests of a community were the interests of the greatest number of men in it; and that therefore every government which rested on the votes of this greatest number, and did not disturb their verdict by collateral influences, would be sure by the nature of the case to promote the true interest of the nation. It has turned out in practice that few men out of a community will give attention to the interests of the community, and that fewer still can see or understand them. Thus the experience of republican government in America has ended in a great deal of disillusion. It is not that men may not be happy and prosperous under republics, but that they are not happier or more prosperous than under many of the forms of monarchy. A people living under republican institutions is plainly not wiser, nor more virtuous, nor more peaceable for its government; nor is this government cheaper or less clumsy in its practical working than others. A certain amount of social ease and independence is attributed to American society by those who have observed it; but it does not appear to have any greater respect or regard for cultivation than the ordinary society of older countries. On the whole, if monarchy and republicanism come into competition, and the victory be decided by the results of experience, there is no particular reason why republicanism should prevail. The probability is, however, that, if the throne were to give place to the presidential chair in a country like ours, the substitution would not be caused by any deliberate preference for republican institutions, but by the aggregation of some or all of those drawbacks on monarchy which we have noticed until they have become intolerable.—*Pall Mall Budget.*

GEOGRAPHICAL EVOLUTION.*

By Professor ARCHIBALD GEIKIE, F. R. S.

I.

IN the quaint preface to his "Navigations and Voyages of the English Nation," Hakluyt calls geography and chronology "the sunne and moone, the right eye and the left of all history." The position thus claimed for geography three hundred years ago by the great English chronicler was not accorded by his successors, and has hardly been admitted even now. The functions of the geographer and the traveler, popularly assumed to be identical, have been supposed to consist in descriptions of foreign countries, their climate, productions, and inhabitants, bristling on the one hand with dry statistics, and relieved on the other by as copious an introduction as may be of stirring adventure and personal anecdote. There has, indeed, been much to justify this popular assumption. It was not until the key-note of its future progress was struck by Karl Ritter, within the present century, that geography advanced beyond the domain of travelers' tales and desultory observation into that of orderly, methodical, scientific progress. This branch of inquiry, however, is now no longer the pursuit of mere numerical statistics, nor the chronicle of marvelous and often questionable adventures by flood and fell. It seeks to present a luminous picture of the earth's surface, its various forms of configuration, its continents, islands, and oceans, its mountains, valleys, and plains, its rivers and lakes, its climates, plants, and animals. It thus endeavors to produce a picture which shall not be one of mere topographical detail. It ever looks for a connection between scattered facts, tries to ascertain the relations which subsist between the different parts of the globe, their reactions on each other and the function of each in the general economy of the whole. Modern geography studies the distribution of vegetable and animal life over the earth's surface, with the action and reaction between it and the surrounding inorganic world. It traces how man, alike unconsciously and knowingly, has changed the face of nature, and how, on the other hand, the conditions of his geographical environment have molded his own progress.

With these broad aims, geography comes frankly for assistance to many different branches of science. It does not, however, claim in any measure to occupy their domain. It brings to the consideration of their problems a central human interest, in which these sciences are sometimes apt to be deficient; for it demands first of all to know how the problems to be solved bear upon the position and history of man and of this marvelously ordered world wherein he finds himself undisputed lord. Geography freely borrows from meteorology, physics, chemistry,

* A Lecture delivered at the Evening Meeting, March 24, 1879.

geology, zoölogy, and botany; but the debt is not all on one side. Save for the impetus derived from geographical research, many of these sciences would not be in their present advanced condition. They gain in vast augmentation of facts, and may cheerfully lend their aid in correlating these for geographical requirements.

In no respect does modern geography stand out more prominently than in the greater precision and fullness of its work. It has fitted out exploratory expeditions, and in so doing has been careful to see them provided with the instruments and apparatus necessary to enable them to contribute accurate and definite results. It has guided and fostered research, and has been eager to show a generous appreciation of the labors of those by whom our knowledge of the earth has been extended. Human courage and endurance are not less enthusiastically applauded than they once were; but they must be united to no common powers of observation before they will now raise a traveler to the highest rank. When we read a volume of recent travel, while warmly appreciating the spirit of adventure, fertility of resource, presence of mind, and other moral qualities of its author, we instinctively ask ourselves, as we close its pages, What may be the sum of its additions to our knowledge of the earth? From the geographical point of view—and it is to this point alone that these remarks apply—we must rank an explorer according to his success in widening our knowledge and enlarging our views regarding the aspects of nature.

The demands of modern geography are thus becoming every year more exacting. It requires more training in its explorers abroad, more knowledge on the part of its readers at home. The days are drawing to a close when one can gain undying geographical renown by struggling against man and beast, fever and hunger and drought, across some savage and previously unknown region, even though little can be shown as the outcome of the journey. All honor to the pioneers by whom this first exploratory work has been so nobly done! They will be succeeded by a race that will find its laurels more difficult to win—a race from which more will be expected and which will need to make up in the variety, amount, and value of its detail, what it lacks in the freshness of first glimpses into new lands.

With no other science has geography become more intimately connected than with geology, and the connection is assuredly destined to become yet deeper and closer. These two branches of human knowledge are, to use Hakluyt's phrase, "the sunne and moone, the right eye and the left," of all fruitful inquiry into the character and history of the earth's surface. As it is impossible to understand the genius and temperament of a people, its laws and institutions, its manners and customs, its buildings, and its industries, unless we trace back the history of that people, and mark the rise and effect of each varied influence by which its progress has been molded in past generations; so it is clear that our knowledge of the aspect of a continent, its mountains

and valleys, rivers and plains, and all its surface features, can not be other than singularly feeble and imperfect, unless we realize what has been the origin of these features. The land has had a history, not less than the human races that inhabit it.

One can hardly consider attentively the future progress of geography without being convinced that, in the wide development yet in store for this branch of human inquiry, one of its main lines of advance must be in the direction of what may be termed geographical evolution. The geographer will no longer be content to take continents and islands, mountain-chains and river valleys, table-lands and plains, as initial or aboriginal outlines of the earth's surface. He will insist on knowing what the geologist can tell him regarding the growth of these outlines. He will try to trace out the gradual evolution of a continent, and may even construct maps to show its successive stages of development. At the same time he will seek for information regarding the history of the plants and animals of the region, and may find much to reward his inquiry as to the early migrations of the fauna and flora, including those even of man himself. Thus his pictures of the living world of to-day, as they become more detailed and accurate, will include more and more distinctly a background of bygone geographical conditions, out of which, by continuous sequence, the present conditions will be shown to have arisen.

I propose this evening to sketch in mere outline the aspects of one side of this evolutional geography. I wish to examine, in the first place, the evidence whereby we establish the fundamental fact that the present surface of any country or continent is not that which it has always worn, and the data by which we may trace backward the origin of the land; and, in the second place, to consider, by way of illustration, some of the more salient features in the gradual growth of the framework of Europe.

The first of these two divisions of the subject deals with general principles, and may be conveniently grouped into two parts: 1. The Materials of the Land. 2. The Building of the Land.

The Materials of the Land.—Without attempting to enter into detailed treatment of this branch of the subject, we may, for the immediate purpose in view, content ourselves with the broad, useful classification of the materials of the land into two great series, (*a*) Fragmental and (*b*) Crystalline.

(*a*.) *Fragmental.*—A very cursory examination of rocks in almost any part of the world suffices to show that by far the larger portion of them consists of compacted fragmentary materials. Shales, sandstones, and conglomerates in infinite variety of texture and color, are piled above each other to form the foundation of plains and the structure of mountains. Each of these rocks is composed of distinct particles, worn by air, rain, frost, springs, rivers, glaciers, or the sea, from previously existing rocks. They are thus derivative formations, and their source,

as well as their mode of origin, can be determined. Their component grains are for the most part rounded, and bear evidence of having been rolled about in water. Thus we easily and rapidly reach a first and fundamental conclusion—that the substance of the main part of the solid land has been originally laid down and assorted under water.

The mere extent of the area covered by these water-formed rocks would of itself suggest that they must have been deposited in the sea. We can not imagine rivers or lakes of magnitude sufficient to have spread over the sites of the present continents. The waters of the ocean, however, may easily be conceived to have rolled at different times over all that is now dry land. But the fragmental rocks contain within themselves proof that they were mainly of marine and not of lacustrine or fluviatile origin. They have preserved in abundance the remains of foraminifera, corals, crinoids, mollusks, annelides, crustaceans, fishes, and other organisms of undoubtedly marine habitat, which must have lived and died in the places where their traces remain still visible.

But not only do these organisms occur scattered through sedimentary rocks; they actually themselves form thick masses of mineral matter. The Carboniferous or Mountain limestone of Central England and Ireland, for example, reaches a thickness of from two thousand to three thousand feet, and covers thousands of square miles of surface. Yet it is almost entirely composed of congregated stems and joints and plates of crinoids, with foraminifera, corals, bryozoans, brachiopods, lamellibranchs, gasteropods, fish-teeth, and other unequivocally marine organisms. It must have been for ages the bottom of a clear sea, over which generation after generation lived and died, until their accumulated remains had gathered into a compact sheet of rock. From the internal evidence of the stratified formations we thus confidently announce a second conclusion—that a great portion of the solid land consists of materials which have been laid down on the floor of the sea.

From these familiar and obvious conclusions we may proceed further to inquire under what conditions these marine formations, so widely spread over the land, were formed. According to a popular belief, shared in perhaps by not a few geologists, land and sea have been continually changing places. It is supposed that while, on the one hand, there is no part of a continent over which sea-waves may not have rolled, so, on the other, there is no lonely abyss of the ocean where a wide continent may not have bloomed. That this notion rests upon a mistaken interpretation of the facts may be shown from an examination—(1) of the rocks of the land, and (2) of the bottom of the ocean.

Among the thickest masses of sedimentary rock—those of the ancient palæozoic systems—no features recur more continually than the alternations of different sediments, and the recurrence of surfaces covered with well-preserved ripple-marks, trails and burrows of annelides, polygonal and irregular desiccation-marks, like the cracks at the bot-

tom of a sun-dried, muddy pool. These phenomena unequivocally point to shallow and even littoral waters. They occur from bottom to top of formations which reach a thickness of several thousand feet. They can be interpreted only in one way, viz., that the formations in question began to be laid down in shallow water; that during their formation the area of deposit gradually subsided for thousands of feet; yet that the rate of accumulation of sediment kept pace on the whole with this depression; and hence, that the original shallow-water character of the deposits remained, even after the original sea-bottom had been buried under a vast mass of sedimentary matter. Now, if this explanation be true, even for the enormously thick and comparatively uniform formations of older geological periods, the relatively thin and much more varied formations of later date can offer no difficulty. In short, the more attentively the stratified rocks of the crust of the earth are studied, the more striking becomes the absence of any formations among them which can legitimately be considered those of a deep sea. They have all been deposited in comparatively shallow water.

The same conclusion may be arrived at from a consideration of the circumstances under which the deposition must have taken place. It is evident that the sedimentary rocks of all ages have been derived from the degradation of land. The gravel, sand, and mud, of which they consist, existed previously as part of mountains, hills, or plains. These materials carried down to the sea would arrange themselves there as they do still, the coarser portions nearest the shore, the finer silt and mud farthest from it. From the earliest geological times the great area of deposit has been, as it still is, the marginal belt of sea-floor skirting the land. It is there that nature has always strewed "the dust of continents to be." The decay of old rocks has been unceasingly in progress on the land, and the building up of new rocks has been as unintermittently going on underneath the adjoining sea. The two phenomena are the complementary sides of one process, which belongs to the terrestrial and shallow oceanic parts of the earth's surface and not to the wide and deep ocean-basins.

Recent explorations of the bottom of the deep sea all over the world have brought additional light to this question. No part of the results obtained by the Challenger Expedition has a profounder interest for geologists and geographers than the proof which they furnish that the floor of the ocean-basins has no real analogy among the sedimentary formations which form most of the framework of the land. We now know by actual dredging and inspection that the ordinary sediment washed off the land sinks to the sea-bottom before it reaches the deeper abysses, and that, as a rule, only the finer particles are carried more than a few score of miles from the shore. Instead of such sandy and pebbly material as we find so largely among the sedimentary rocks of the land, wide tracts of the sea-bottom at great depths are covered with various kinds of organic ooze, composed sometimes of minute calcareous forami-

nifera, sometimes of siliceous radiolaria or diatoms. Over other areas vast sheets of clay extend, derived apparently from the decomposition of volcanic detritus, of which large quantities are floated away from volcanic islands, and much of which may be produced by submarine volcanoes. On the tracts farthest removed from any land the sediment seems to settle scarcely so rapidly as the dust that gathers over the floor of a deserted hall. Mr. Murray, of the Challenger staff, has described how from these remote depths large numbers of sharks' teeth and ear-bones of whales were dredged up. We can not suppose the number of sharks and whales to be much greater in these regions than in others where their relics were found much less plentifully. The explanation of the abundance of their remains was supplied by their varied condition of decay and preservation. Some were comparatively fresh, others had greatly decayed, and were incrusted with or even deeply buried in a deposit of earthy manganese. Yet the same cast of the dredge brought up these different stages of decay from the same surface of the sea-floor. While generation after generation of sea creatures drops its bones to the bottom, now here, now there, so exceedingly feeble is the rate of deposit of sediment, that they lie uncovered, mayhap, for centuries, so that the remains which sink to-day may lie side by side with the moldered and incrusted bones that found their way to the bottom hundreds of years ago.

Another striking indication of the very slow rate at which sedimentation takes place in these abysses has also been brought to notice by Mr. Murray. Among the clay from the bottom he found numerous minute spherical granules of native iron, which, as he suggests, are almost certainly of meteoric origin—fragments of those falling stars, which, coming to us from planetary space, burst into fragments when they rush into the denser layers of our atmosphere. In tracts where the growth of silt upon the sea-floor is excessively tardy, the fine particles, scattered by the dissipation of these meteorites, may remain in appreciable quantity. In this case, again, it is not needful to suppose that meteorites have disappeared over these ocean-depths more numerously than over other parts of the earth's surface. The iron granules have no doubt been as plentifully showered down elsewhere, though they can not be so readily detected in accumulating sediment. I know no recent discovery in physical geography more calculated to impress deeply the imagination than the testimony of this meteoric iron from the most distant abysses of the ocean. To be told that mud gathers on the floor of these abysses at an extremely slow rate, conveys but a vague notion of the tardiness of the process. But to learn that it gathers so slowly that the very star-dust which falls from outer space forms an appreciable part of it, brings home to us, as hardly anything else could do, the idea of undisturbed and excessively slow accumulation.

From all this evidence we may legitimately conclude that the pres-

ent land of the globe, though formed in great measure of marine formations, has never lain under the deep sea; but that its site must always have been near land. Even its thick marine limestones are the deposits of comparatively shallow water. Whether or not any trace of aboriginal land may now be discoverable, the characters of the most unequivocally marine formations bear emphatic testimony to this proximity of a terrestrial surface. The present continental ridges have probably always existed in some form, and as a corollary we may infer that the present deep ocean-basins likewise date from the remotest geological antiquity.

(*b*.) *Crystalline.*—While the greater part of the framework of the land has been slowly built up of sedimentary materials, it is abundantly varied by the occurrence of crystalline masses, many of which have been injected in a molten condition into rents underground, or have been poured out in lava-streams at the surface.

Without entering at all into geological detail, it will be enough for the present purpose to recognize the characters and origin of two great types of crystalline material which have been called respectively the Igneous and Metamorphic.

1. *Igneous.*—As the name denotes, igneous rocks have risen from the heated interior of the earth. In a modern volcano, lava ascends the central funnel, and, issuing from the lip of the crater or from lateral fissures, pours down the slopes of the cone in sheets of melted rock. The upper surface of the lava column within the volcano is kept in constant ebullition by the rise of steam through its mass. Every now and then a vast body of steam rushes out with a terrific explosion, scattering the melted lava into impalpable dust, and filling the air with ashes and stones, which descend in showers upon the surrounding country. At the surface, therefore, igneous rocks appear, partly as masses of congealed lava, and partly as more or less consolidated sheets of dust and stones. But beneath the surface there must be a downward prolongation of the lava column, which no doubt sends out veins into the rents of the subterranean rocks. We can suppose that the general aspect of the lava which consolidates at some depth will differ from that which solidifies above-ground.

As a result of the revolutions which the crust of the earth has undergone, the roots of many ancient volcanoes have been laid bare. We have been as it were admitted into the secrets of these subterranean laboratories of nature, and have learned much regarding the mechanism of volcanic action, which we could never have discovered from any modern volcano. Thus, while on the one hand we meet with beds of lava and consolidated volcanic ashes, which were undoubtedly erupted at the surface of the ground in ancient periods, and were subsequently buried deep beneath sedimentary accumulations now removed, on the other hand, we find masses of igneous rock which certainly never came near the surface, but must have been arrested in their ascent from be-

low, while still at a great depth, and have been laid bare to the light after the removal of the pile of rock under which they originally lay.

By noting these and other characters, geologists have learned that, besides the regions of still active volcanoes, there are few large areas of the earth's surface where proofs of former volcanic action or of the protrusion of igneous rocks may not be found. The crust of the earth, crumpled and fissured, has been, so to speak, perforated and cemented together by molten matter driven up from below.

2. *Metamorphic.*—The sedimentary rocks of the land have undergone many changes since their formation, some of which are still far from being satisfactorily accounted for. One of these changes is expressed by the term *Metamorphism,* and the rocks which have undergone this process are called *Metamorphic.* It seems to have taken place under widely different conditions, being sometimes confined to small local tracts, at other times extending across a large portion of a continent. It consists in the rearrangement of the component materials of rocks, and notably in their recrystallization along particular lines or laminæ. It is usually associated with evidence of great pressure; the rocks in which it occurs having been corrugated and crumpled, not only in vast folds, which extend across whole mountains, but even in such minute puckerings as can only be observed with the microscope. It shows itself more particularly among the older geological formations, or those which have been once deeply buried under more recent masses of rock, and have been exposed as the result of the removal of these overlying accumulations. The original characters of the sandstones, shales, grits, conglomerates, and limestones, of which no doubt these metamorphic masses once consisted, have been almost entirely effaced and have given place to that peculiar crystalline laminated or foliated structure so distinctively a result of metamorphism.

An attentive examination of a metamorphic region shows that here and there the alteration and recrystallization have proceeded so far that the rocks graduate into granites and other so-called igneous rocks. A series of specimens may be collected showing unaltered or at least quite recognizable sedimentry rocks at the one end, and thoroughly crystalline igneous rocks at the other. Thus the remarkable fact is brought home to the mind that ordinary sandstones, shales, and other sedimentary materials may in the course of ages be converted by underground changes into crystalline granite. The framework of the land, besides being knit together by masses of igneous rock intruded from below, has been strengthened by the welding and crystallization of its lowest rocks. It is these rocks which rise along the central crests of mountain-chains, where, after the lapse of ages, they have been uncovered and laid bare, to be bleached and shattered by frost and storm. —*Proceedings of the Royal Geographical Society.*

SKETCH OF PROFESSOR DANIEL VAUGHAN.

We have already printed in our May number a brief sketch of the life of Professor Vaughan, with the particulars of the painful circumstances attending his death, and a list of his more important scientific papers. That sketch comprises the history of Vaughan's life, so far as it is known, and there remains nothing more to add to it.

It is not a little singular that among the property which he left only one piece of unpublished MS. was found. Remarking on this fact, Mr. Richard Nelson writes in the "Cincinnati Commercial": "As early as 1857 he had occasion to complain that one of his discoveries had been claimed by a prominent scientist. That made him suspicious, and, as a result of his solitary life, suspicion, like a disease, grew upon him to that extent that at one time his intimate friends feared it would overpower his giant intellect. To prevent the recurrence of the annoyance he afterward chose to store away in his wonderfully capacious and retentive memory facts, principles, and figures, till the opportune moment of publication arrived, and then, instead of sending his manuscript to the publishers, he had his articles printed and simultaneously mailed to the publishers and distinguished scientists in various parts of the world. These are the printed articles found among his effects."

The unpublished MS. mentioned above was on "The Origin of the Asteroids," and is marked by all the best characteristics of the author's style. While extremely brief, it treats the subject thoroughly. This paper is printed in our August Miscellany.

We have been called upon to qualify somewhat the statements made in the "Monthly" reflecting upon the citizens of Cincinnati for neglecting this man in his poverty, and leaving him to die in want. It turns out that Vaughan was a man destitute of common sense in the matter of taking care of himself, and that he was perverse in not allowing others to assist him. With his penury he was eccentric, and carefully secluded himself from attention, so that it was difficult to find him. It is said there were many who would gladly have assisted him, and that, too, in a way not to wound his feelings, if he had given them the opportunity, but that he obstinately refused to receive assistance. He was probably intractable in this respect, for which there may have been much excuse, for he may have felt that he was entitled to something better than charity, and, if he could not get what was his due, he would not take pittances. Perhaps, if there had been more solicitude about him, more might have been done for him; but it is quite probable that Cincinnati is not worse than other cities in its want of active sympathy for the suffering.

EDITOR'S TABLE.

THE BENNETT EXPEDITION TO THE NORTH POLE.

THE unknown spaces of the earth's surface are being rapidly narrowed by the enterprise of indefatigable explorers. Some considerable patches remain that have not been penetrated, but their collective area is relatively small. There is a large region in the interior of Australia that has not been traversed, owing to the absence of water and vegetation. Central Africa is the field where the geographical discoverer has recently made his most brilliant conquests, both by narrowing the outline of the unknown region, and by the importance of the knowledge that has been gained. Less than half a century ago inner Africa was supposed to be in a great measure an arid and unproductive desert; but the explorations of Livingstone and Stanley have proved it to be well watered, fertile, and densely populated. There has been less success with Arctic exploration, though it has been vigorously pushed for the last fifty years. Latitude 83° 26′ is the northernmost point hitherto reached by any explorer. This leaves an unpenetrated blank surrounding the north pole which at the narrowest point is about 800 miles across. There is little promise of any commercial utility that can come from getting access to this frigid region, but it is enough that it is a mystery which the whole civilized world has determined, if possible, to clear up, and in doing this the rivalries of national enterprise have been called into active play.

It is fortunate for geographical progress that the proprietor of the "New York Herald," Mr. James Gordon Bennett, not altogether satisfied with the excitements of yacht-racing, has developed an ambition in the direction of exploring unknown tracts of the earth's surface. He has spent a good deal of money on mid-Africa with highly satisfactory results, and now turns the princely revenues of his newspaper into a channel for the promotion of Arctic research. It is an expensive business, as the cost of Arctic expeditions has increased from $30,000, three hundred years ago, to $4,166,665 for the Franklin expeditions of 1848–'54. Mr. Bennett, after furnishing the necessary funds, and preparing the expedition, has made it a national affair by requesting the United States Government to take charge of it. By act of Congress it has been put in control of naval officers, and is cared for by the Navy Department. Besides these peculiarities of the project, it is novel as being the first Arctic expedition fitted out from the west coast of the continent, and which proposes to push forward to the north pole by the way of Behring Strait. According to Lieutenant De Long, commander of the Jeannette, which carries the exploring party, no vessel has penetrated farther north by this route than latitude 71°. Beyond that parallel the explorers will encounter a hitherto unobserved region.

A new element comes into play in this venture which has been thus far regarded by Arctic navigators as one of peril. In the other routes that have been taken to reach the pole the currents set downward, so that if the adventurers have to abandon their ship and take to the ice they have a chance of being brought back, as was marvelously exemplified by the ride of Tyson's party. But on the Pacific side there is a current of water known as the Kuro Shiwo, or Japanese Warm-Stream, a branch of

which is known to enter the Arctic Sea through Behring Strait, and is believed to emerge on the other side through Baffin's Bay. The drift of ice on this side is consequently northward, and the danger is that it will cut off the retreat in case of accident to the ship by which the party is compelled to take to the ice.

Of course the object of the expedition is to reach the north pole, but, even if it fails, there are subsidiary objects also to be accomplished. It may be expected, at any rate, that the unknown Arctic area will be reduced in dimensions, and there will be the opportunity of scientific observations in places as yet unexplored. The magnetic conditions north of the magnetic pole will be examined. There will be geological and mineralogical observations, and information collected with reference to the fauna and flora of the Arctic regions. Systematic attention will also be given to meteorology, in the hope of getting further data for elucidating the laws of storms.

The scientists of the Western coasts, as is very natural, have taken a deep interest in this first Arctic expedition from their side, and that has so many special features of importance. A meeting of the Academy of Sciences in San Francisco was convened June 16th, for the special purpose of giving a reception to Lieutenant De Long and the staff of the Bennett expedition. A paper on Arctic exploration was read by Dr. A. B. Stout, and remarks were made upon various connected topics by gentlemen present. Lieutenant De Long spoke, but only to say that he had very little to say in regard to what they were going to do. They did not sufficiently know themselves, and hoped to be better qualified to talk satisfactorily upon their return. Mr. Charles Wolcott Brooks made some interesting observations regarding the ethnological possibilities of the Arctic regions which we here subjoin: "In offering his word of kind encouragement, he remarked that men who use obstacles as stepping-stones to success are apt to win; and he but expressed the universal desire of all ethnologists that Lieutenant De Long and his brave comrades should overcome every barrier that the Frost King might impose as an obstacle to their success. As ethnologists, we all feel great interest in the existence of an Arctic Continent, and earnestly desire to know if it is, or can be, inhabited. In a world governed by mathematical law, whose every atom is geometrically correct, and subject to mathematical proof, we may reasonably judge of the unknown by what we can see, cautiously using the great law of analogy as our guide. If we should judge of the ultimate atom, or the most distant orb in space, we may study for that purpose some object around us, or our globe taken as a whole. He who has watched the organization of crystalline forms under electric currents has seen the operation of the same law which has formed the solid part of the earth we live on. In its early and plastic condition it was a sphere like the dew-drop, but, with the constant currents of organizing magnetism, it has assumed a crystalline form, and to-day its solid exterior, were its oceans emptied and removed, would present the polyhedron. If we carefully examine the almost universal features of all land known to us, we find a prevailing form wherever we turn. Each territorial area of magnitude seems to have an appendage trending southward. Thus, south of the large continent of North America, we find that leg-of-mutton or *pend d'oreille* form of South America. Beneath Europe rests a similar shaped area of land in the continent of Africa, and south of Asia is Australia and the Polynesian or Spice Islands. The same relative position of land is general among many island groups, and all peninsulas seem also to point southward, such as Kamtchatka, Alaska, Lower California, Florida, Nova

Scotia, Hindostan, etc., and all such forms have larger bodies of land to their north. Now, if we apply this rule, by turning the north pole of a globe toward us, we readily see at a glance that Greenland, which is known to us, may bear to an unknown Arctic Continent the same relation that South America does to North America, or Africa to Europe. Hence it is perfectly logical to infer, by the great analogy of nature, that an Arctic Continent exists beneath the north pole, extending three and a half to four degrees south from the northern axis of the world. As previous Arctic expeditions have advanced to 83° 26′ north latitude—or within 394 miles of the pole—the distance thence to such a continent would not exceed 150 to 180 miles. This intervening space, however, is quite difficult to traverse, as it is represented to present a very rough surface. If the sea, during the height of a gale, when waves run mountains-high, were instantly frozen, it would present much the appearance here encountered. Now, for ethnologists, the question is, Can an Arctic Continent be inhabited, should one exist? This may be met by the already expressed surmise that the latitude of 78° is about the point of lowest mean temperature. The earth is about thirty-seven miles more in diameter at the equator than from pole to pole, having enlarged at one point and flattened at another, because of its revolving motion. Now, it is well known that lower temperatures are encountered as we ascend great altitudes, and the depression at the poles may, by lessening the distance of the surface from the earth's center, afford a warmer temperature, which will enable the hardy Esquimaux, Ainos, or some hyperborean race, to exist upon an Arctic Continent. Should such prove to be the case, and our good friends discover any races there to us unknown, we shall look to them to resurrect us a specimen skull of some departed inhabitant."

THE PRINCE IMPERIAL.

MUCH regret is expressed at the sad end of the late descendant of the Napoleons and heir-apparent to the throne of France; and much sympathy has also been awakened for the exiled and widowed mother now made childless. The bereaved woman is entitled to the same sympathetic consideration as any other poor widow who has lost an only child; for, though in her case there may be a peculiar bitterness in the crushing of ambitious hopes, she has yet the mitigations of royal condolence, and the assurance that her griefs are shared by sympathetic multitudes. As for the dead Prince, we might say that his premature cutting off is just as deplorable as the killing of other young soldiers in the common fortunes of war.

But is this quite true? At any rate, if it is a blessed thing to lay down one's life for one's country, is not the amiable young Prince to be deemed fortunate, for certainly his death is the greatest boon that it would be possible for the French nation now to receive? Again, according to the code of military honor, he is to be congratulated in having lost his life in war, whether his country benefited or lost by it; and especially so as the other Napoleons have died peacefully and ingloriously in their beds, while it has been reserved for the last of the line to perish, if not on the field of battle, at least by violence and in war. Belonging to a race of adventurers, he fitly died as an adventurer; and, although the manner of his going was not very dignified, history will still be able to say that one Bonaparte was sacrificed to the vocation to which they were all devoted.

There is, however, one aspect of this transaction that may be referred to as an illustration of the selfish brutality of the common ethics of war. When the military system is arraigned as the great anomaly of civilization, and war as the most stupendous curse of humanity, we are told that nations

must defend themselves, and that war is therefore a necessary evil, to be avoided whenever possible, and always mitigated to the utmost in its sufferings and its horrible waste of life. And yet when men go into it in cold blood as a business, regardless of its justice, and purely for the promotion of a selfish ambition, their conduct still meets with unbounded applause. It is said to be to the credit of the young Prince that he generously offered his services to England to fight the Zulus; but what business had this young Frenchman with the Zulu war? What had these distant Africans ever done, that he should desire to join in the work of killing them? He not only mixed up with what was none of his concern, but he espoused the cause of the wanton aggressor, for a greater outrage was never perpetrated than this British invasion of the Zulu people. But it is in accordance with military traditions and usages for ambitious men to seize any opportunity of making their mark. The Count of Paris came over to have a hand in our own glorious civil war, took sides, and went into the business of killing Southerners for the noble purpose of acquiring military prestige that might commend him to the French, and thus increase his chances of being accepted for the throne of that nation. The Prince Imperial "went to war" for the same purpose, that he might make a military name, and thus improve his chances of getting control of the French army at some future crisis, and play the despot like his predecessors. He followed a detestable practice for a villainous purpose, and got his just reward.

"AMERICA'S PLACE IN HISTORY."

Under this title, Mr. John Fiske, of Cambridge, Massachusetts, formerly lecturer on Philosophy in Harvard University, has prepared a course of popular lectures which will be found worthy the attention of such associations as can appreciate first-rate intellectual work. Mr. Fiske is author of the "Cosmic Philosophy," and a thorough student of the modern tendencies of thought. He gave these lectures in Boston not long ago, and they made so excellent an impression that he was called to repeat them in London, and left early in June for that purpose. Mr. Fiske is well prepared by his philosophical and historical studies to give to the problem he has taken up an original and independent treatment. Familiar with the principles of social evolution, and having given much attention to the study of races, and to ethnological interactions in the progress of modern society, he is well prepared to handle the large and complex questions involved in the settlement of America, the organization of colonial institutions, the establishment of the American Republic, and the development of free government on this continent. The prospectus of this course of lectures is before us, and it is rich in topics that must deeply interest all thoughtful Americans. These are the sort of lectures that deserve encouragement and are worth working for.

The senior editor of this magazine also proposes to betake himself somewhat to his old business of lecturing during the coming season. For particulars address E. L. Youmans, office of "The Popular Science Monthly," New York.

LITERARY NOTICES.

The International Scientific Series, No. XXVII. The Human Species. By A. De Quatrefages, Professor of Anthropology in the Museum of Natural History, Paris. New York: D. Appleton & Co. Pp. 498. Price, $1.75.

The accomplished French anthropologist has here produced a remarkably attractive book. It is written with all that clearness and vivacity of manner for which

skillful literary Frenchmen are remarkable, and the translator has well reproduced the art of the author. This, however, is but an incidental though important trait of the volume; its interest centers in the scientific treatment of a vast subject, in the admirable classification of its materials, the incisiveness of the dialectics, and the wealth of information to elucidate and illuminate a great branch of inquiry. De Quatrefages is, moreover, a man of moderate views, a cautious and disciplined investigator, and who, by long familiarity with his subject, speaks with authority, and may be trusted in the representation of his facts.

His work is divided into ten Books, the first of which consists of eleven chapters, in which he discusses in its various aspects the "Unity of the Human Species." The anthropological method is first treated with a general statement of anthropological doctrines. The problem of species and race in the natural sciences is then taken up, and the nature and extent of variations in animal and vegetable races, with their applications to man, are considered. The fusion of characters, and the crossing of races and species in the animal and vegetable kingdoms, are next dealt with, and the conclusions applied to the human race. The human groups obey the laws of crossing, and from his wide survey of the facts the author arrives at the conclusion that all men belong to the same species, and that there is but one species of man.

Book II. takes up the vexed question of the "Origin of the Human Species," which is dealt with in two chapters. There is here a sharp discussion of Darwinism, in which the author refuses to accept the conclusions of the British zoölogist. He admits the principle of natural selection as both a true cause and an important agency in producing the changes of the living world; but he totally denies that this principle is adequate to produce transformations of species or to originate new species. He praises Darwin's accomplishments as a biologist, and acknowledges the indebtedness of science to his investigations, but will not for a moment recognize that he has accounted for the origin of man. On this question he takes the conservative side, and, while cordially commending the vigorous work of advanced naturalists, and recognizing that valuable results may flow from it, he still avows himself as belonging to the old school. Of the origin of life the author says we know nothing, and "all who wish to remain faithful to true science will accept the existence and succession of species as a primordial fact. He will apply to all what Darwin applies to his single *prototype*." We will refer to this matter again presently.

Book III. takes up the question of the "Antiquity of the Human Species," and gives a succinct account of the relation of man to present and past geological epochs in two chapters.

Book IV. devotes also two chapters to the "Original Localization of the Human Species," and, of course, raises the question of centers of creation and unity or plurality of origins. Agassiz is taken as the ablest representative of the latter doctrine, which is criticised by Professor De Quatrefages with great force. One of the most interesting problems that will have to be worked out one of these days is that of the mental bias and incompetency of judgment acquired by scientific men as a result of their special branches of study. Professor De Quatrefages gives an interesting illustration of this in the case of Agassiz. He says: "There are singular points of resemblance and no less striking contrasts between Agassiz and the most extravagant disciples of Darwin. The illustrious author of the 'Essay on Classification' is as exclusive a morphologist as the latter: neither in his opinion nor in theirs does the idea of filiation form any connection with that of species; he declares, as they do, that the questions of crossing, of constant or limited fertility, have no real interest. We are justified in attributing these opinions, so strange in such an eminent zoölogist as Agassiz, to the nature of his early works. It is well known that he commenced his career with his celebrated researches upon fossil fishes. We have already remarked upon the influence which is almost inevitably exercised by fossils where form alone has to be considered, where nothing calls attention to the genealogical connection of beings, and where we meet with neither parents nor offspring."

Having given illustrations of the way Agassiz, in the heat of controversy, was led on to untenable positions so that at last he denied even the filiations of languages, Professor De Quatrefages proceeds: "Agassiz, when he had arrived at this point, must have felt that he had lost himself, and that in trying to harmonize the idea of a single human species with that of several races of distinct origin he was entering an endless labyrinth. His last work betrays the signs of this embarrassment only too clearly. It is probably in the hope of escaping from it that the author has finally even denied the existence of species. After having again rejected the criterion drawn from crossing and degrees of fertility, he adds: 'With it disappears in its turn the pretended reality of species as opposed to the mode of existence of genera, families, orders, classes, and branches. Reality of existence is in fact possessed by individuals alone.' Thus from adhering solely to morphology from a disregard of the physiological side of the question, from having allowed themselves to be guided by a logic which is only founded upon incomplete data, Agassiz and Darwin have arrived at a similar result. Both have disregarded this great fact intelligible to common sense, demonstrated by science, and which governs everything in zoölogy as it does in botany, the division, namely, of organized beings into elementary and fundamental groups which propagate in space and time. But Darwin, starting from the phenomena of *variations* which are presented by these beings, considers species only as races. Agassiz, entirely preoccupied with the phenomena of *fixity*, finally considers individuals only as existing in living nature."

This is the proper place to suggest that De Quatrefages himself is perhaps open to criticism from the point of view of studies that disturb the judgment. While there is force in the point he makes against Darwinism, that natural selection is insufficient to account for evolution, the same thing is pointed out by eminent evolutionists, and Darwin himself has admitted that he at first made too much of the principle. De Quatrefages makes the common mistake of considering Darwinism and evolution as the same thing. We should say that the logical fault of De Quatrefages is that he does not allow sufficient weight to that already overwhelming consensus of proofs, and which is every day becoming stronger, that evolution is a great fact of nature, which must be accepted in its interpretation whatever outstanding difficulties remain yet to be cleared up.

Book V., on the "Peopling of the Globe," deals with the interesting subject of the migration of populations by sea and land. Book VI. takes up the "Acclimatization of the Human Species," and deals with the influence of conditions on life and race. Book VII. discusses "Primitive Man—Formation of the Human Races." In Book VIII. four interesting chapters are given to "Fossil Human Races." Book IX. considers the "Physical Characters of Present Human Races," anatomical, physiological, and pathological. Book X. closes the work by an "Analysis of the Psychological Characters of the Human Species," including its intellectual, moral, and religious characters.

To those in want of a well-digested summary of anthropological science, done in a most readable form, this volume may be freely commended.

A Practical Treatise on the Combustion of Coal, including Descriptions of Various Mechanical Devices for the Economic Generation of Heat by the Combustion of Fuel, whether solid, liquid, or gaseous. By William M. Barr. Indianapolis: Zohn Brothers. Pp. 306. Price, $2.50.

This seems a very well-digested compilation of a large amount of useful information upon a subject of much technical interest and importance. Coal has already come into so extensive use as a source of heat, both for warmth in private houses and as a motive power in manufactures, and its consumption for these ends is certain to be so greatly increased in future, that the question of the best methods of using it, in various circumstances, in order to make its force more perfectly available, is one of much practical moment. It is a subject well fit to be treated separately, and Mr. Barr's volume goes over it in a quite detailed and ample way. No better idea of the fullness of the work can be gained than by giving an inventory of its

chapters. The first is preliminary, on the physical properties and sources and formation of coal. This is followed by "The Atmosphere," "Fuels," "Analysis of Coal," "Combustion," "Air required for Furnace Combustion," "The Furnace," "Products of Combustion," "Thermal Power of Fuels," "Heat," "The Construction of Furnaces," "Mechanical Firing," "Spontaneous Combustion of Coal," "Coal-Dust Fuel," "Liquid Fuel," "Gaseous Fuel," "Utilizing Waste Gases from the Furnace," "A. Pousard's Process and Apparatus for generating Gaseous Fuel."

Man's Moral Nature: An Essay. By Richard Maurice Bucke, M. D., Medical Superintendent of the Asylum for the Insane, London, Ontario. New York: G. P. Putnam's Sons. Pp. 200. Price, $1.50.

The author of this book, who ought to know the most about it, indicated its scope and the purpose he had in writing it in the following introductory passage:

> The object of this essay is to discuss the moral nature—to point out, in the first place, its general relation to the other groups of functions belonging to, or rather making up, the individual man, and also its relations to man's environment. Secondly, to show its radical separation from these other groups of functions; then to attempt to decide of what organ it is a function—to consider whether it is a fixed quantity, or whether, like the active nature and the intellectual nature, it is in course of development. And, if the moral nature is progressive, to try to find out what the essential nature of this progress is—upon what basis the progress itself rests—the direction of the progress in the past and in the future—its causes—its history—and the law of it—and to point out the conclusions which can be drawn from this progress as to the character of the universe in which we live.

We hardly think, however, that the work can be classed among important contributions to the progress of ethical science. It seems to stand, in fact, in the same relation to the constitution of the moral world that the old doctrine of the four elements—fire, air, earth, and water—stood to the constitution of the physical world. There were ingenuity and a crude utility, when nothing was known of nature, in this conception of four elemental constituents by the endless commixture of which all natural things were accounted for, but it would not be a step forward to revive it now. Dr. Bucke takes, as the foundation of his ethical system, the four simple moral elements—faith, love, hate, and fear—and, by combinations of these with each other, and with still other ideas, he aims to solve all moral problems and account for all moral phenomena. He is a physician, and links his theory with physiological and anatomical science, by assuming that the sympathetic system is the nervous center of the moral nature. He gives woodcuts of the ganglionic chains, of the cerebro-spinal and great sympathetic nerves, accompanied with an interesting account of their anatomical structure and physiological functions, and he assumes the moral relations of the sympathetic system because of its intimate association with the emotional life.

The Reign of the Stoics: History, Religion, Maxims of Self-Control, Self-Culture, Justice, Philosophy. With Citations of Authors quoted from each page. By Frederick May Holland. New York: Charles P. Somerby. Pp. 248. Price, $1.25.

Mr. Mill, in his celebrated St. Andrew's defense of classical studies in modern education, in replying to the charge that there is little valuable information to be got out of old Greek and Latin books, declared that ancient literature contains a great deal of "the wisdom of life" which may be profitably studied in these times. He did not say what there was about this wonderful wisdom that should make it necessary, after two thousand years of further experience, and all the vast developments of modern knowledge, that our youth should be compelled to learn two dead languages in order to arrive at it. Precious, indeed, must be that "wisdom of life" which is incapable of being transferred from one form of speech to another. The compiler of the volume before us quite fails to see Mr. Mill's point, and has gone about the task of importing the said wisdom of the ancients into the English tongue, so that it may be made available by multitudes who know nothing of the classical languages. The first chapter is a kind of historical essay relating to the ancient Stoical moralists. Chapter II. is devoted to religion; Chapter III. to maxims of self-control; Chapter IV. to maxims of self-culture; Chapter V. to maxims of benevo-

lence; Chapter VI. to maxims of justice; and Chapter VII. is a kind of essay on the ancient philosophy. The compiler has raked together from all sources a mass of fragmentary proverbs, aphorisms, sentiments, and wise sayings, which are no doubt quite as sound and instructive, but not half as pungent and readable, as the saws of Sancho Panza. On the whole, we think that Mill is about right, and that people will appreciate this wisdom a great deal higher after they have mastered a couple of languages in order to get at it.

THE TEMPERAMENTS; OR, THE VARIETIES OF PHYSICAL CONSTITUTION IN MAN CONSIDERED IN THEIR RELATIONS TO MENTAL CHARACTER AND THE PRACTICAL AFFAIRS OF LIFE. By D. H. JACQUES, M. D. New York: S. R. Wells & Co. 1878. Pp. 239. $1.50.

THE editor of this volume, in the introduction, remarks that the "literature of the temperaments is very scanty." The reason of this doubtless is, that scientific investigators have not hitherto regarded the temperaments as a very fruitful field of study. According to Dr. Jacques, however, there is no study, not even, perhaps, phrenology itself, which can be of greater service to us in acquiring a knowledge of ourselves and our fellow men. Those who may happen to coincide with this view, and suppose that they can gain "practical guidance in the affairs of life" by closely observing differences of temperament, will do well to consult Dr. Jacques's well-written little work.

COLOR-BLINDNESS, ITS DANGERS AND ITS DETECTION. By B. JOY JEFFRIES, A. M., M. D. Boston: Houghton, Osgood & Co. Pp. 312. Price, $2.

THIS subject, which is one of much scientific interest and practical importance, has engaged the attention of many inquirers during the past and present generations. That defect of vision by which certain colors can not be discriminated, and by which one is mistaken for another, and which is now well established as congenital and as very common, has no doubt existed at all times, though its detection is modern and its scientific elucidation comparatively recent. The first well-authenticated case of color-blindness was of an English shoemaker, named Harris, one hundred years ago. But the first marked instance attracting general attention was that of the English chemist, Dalton, who described his own case in 1794, so that this chromatic defect went for some time under the name of Daltonism. The tests of this deficiency have now been carefully worked out and observations made in different countries upon great numbers of persons, bringing out the general result, that about four per cent. of the persons inspected suffer from this defect in a greater or less degree, some being incapable of recognizing one color, and some another. Dr. Jeffries treats the subject systematically and fully in his volume, giving great numbers of cases and digesting all the results of the investigation in different countries. It is found that this failure of vision is so frequent that it has been necessary to institute government inspection of men in all those public employments where erroneous vision might lead to danger, as where colored signals are employed upon railroads and in navigation. In Chapter XXIII. of his book, Dr. Jeffries gives an account of the European and Massachusetts legislation which has been resorted to, to obtain security from errors of this kind.

MONEY, TRADE, AND INDUSTRY. By FRANCIS A. WALKER, Professor of Political Economy and History in the Sheffield Scientific School of Yale College. New York: Henry Holt & Co. Pp. 339. Price, $1.25.

WE have here from the pen of the Superintendent of the United States Census, and author of "The Statistical Atlas of the United States," a very important contribution to certain aspects of political economy that are of the highest moment to the people of the United States. Professor Walker published a work on "Money" last year, written from the historical standpoint, and designed to introduce the student to the literature of the subject. The present work aims to make a direct popular statement of principles, without giving the history of their derivation; and it differs from the other book also by taking in the relations of money to trade and industry. The volume is therefore practical in its scope, and has been adapted, with excellent judgment, both to the popular capacity of apprehending economical inquiries and to the most urgent

wants of this country at the present time for sound information. Whatever may be the unattractiveness of the "dismal science," we are satisfied that a large share of it is due to the culpable dullness of writers on economics. If a book upon money is stupid, the author must take the responsibility, for his subject is in his favor, and he may count upon the interest of his reader if he does not succeed in extinguishing it. Professor Walker writes with a vigorous directness, a clearness of perception, and an artistic skill in the use of examples and illustrations, which give a keen pleasure to the reader, and make every chapter of his book entertaining as well as instructive. His views are stated with an epigrammatic point and argumentative force that will make the perusal of his book a pleasure to all into whose hands it may fall. Embroiled as we are in this country in conflicts of opinion upon all aspects of the money question—coinage and paper currency, mono-metalism and bi-metalism, depreciation and appreciation, expansion and contraction, high and low interest, national issues and banking agencies, and scores of other monetary problems—nothing is more needed than able popular presentations of the principles that underlie all this complex system of financial phenomena, and we have seen no book better adapted to clarify the public mind upon these subjects than this of Professor Walker.

Birds of the Colorado Valley. By Elliott Coues. With numerous Illustrations. Washington: Government Printing-Office. 1878. Pp. 823.

In preparing this work, Dr. Coues has undertaken a vast amount of labor. The whole subject of the bibliography of North American ornithology and of the synonomy of North American birds has been worked up anew from the very bottom, and nothing is given at second hand. Not only the birds of the Colorado Valley, but also all others of North America, are thus exhaustively treated. The popular character of this treatise is very marked. "Respecting the biographies or *life history* of the birds which constitute the main text of the present volume," writes Professor Hayden, "the author's view, that this portion of the subject should be so far divested of technicality as to meet the *tastes and wants of the public*, rather than the scientific requirements of the schoolmen in ornithology, will doubtless meet with general and emphatic approval." The volume before us forms Part I. of the treatise, "Passeres to Laniidæ."

Aids to Family Government: or, From the Cradle to the School, according to Froebel. By Bertha Mayer. Translated from the German by M. L. Holbrook, M. D. With an Essay on the Rights of Children and the True Principles of Family Government. By Herbert Spencer. New York: M. L. Holbrook & Co. Pp. 208.

This book mainly consists of a translation of a little treatise on early education, said to be very popular in Germany. It is devoted to Pestalozzi, Froebel, and Kindergartens, and some useful hints may be picked out of it, though it will be chiefly useful in swelling the tide of Kindergarten literature, which is just now in fashion. The name of Herbert Spencer appears upon the cover of the title-page as author of a part of the book, and there are a dozen pages of extracts from him at the end. But from which of his works they are taken, or in what connection they are to be found, is not stated. The quotations, however, on the rights of children, are from a volume printed by Spencer twenty-nine years ago, parts of which he has since disavowed as no longer representing his views, and among them is the chapter on the rights of children.

The Beneficial Influence of Plants. By J. M. Anders, M. D., Ph. D. Pp. 12.

This paper treats of the old question of the influence of plants in houses on the conditions of health. The author is inclined to agree with Pettenkofer, that, as decomposers of carbonic-acid gas or as generators of ozone, plants in rooms are really of little or no value; but, as a means of supplying moisture to the air of furnace-heated houses by the process of transpiration, they become important agents in promoting the health of the inmates. This conclusion is based on the writer's own investigations, the results of which are given in the paper.

PUBLICATIONS RECEIVED.

Roman Catholicism in the United States. New York: Authors' Publishing Company. 1879. Pp. 186. Price, $1.25.

The Round Trip. By John Codman. New York: Putnam's Sons. 1879. Pp. 331. $1.50.

Lectures on the History of England. By M. J. Guest. London and New York: Macmillan. 1879. Pp. 568. $1.75.

Outlines of Field Geology. By A. Geikie. London and New York: Macmillan. 1879. Pp. 222. $1.

Long Life, and how to reach it. By Joseph G. Richardson, M. D. Philadelphia: Lindsay & Blakiston. 1879. Pp. 160. 50 cents.

Cultivation of the Senses. Philadelphia: Eldridge & Brother. Pp. 96. 50 cents.

Is Life worth living? By W. H. Mallock. New York: Putnam's Sons. 1879. Pp. 323. $1.50.

Relations of Mind and Brain. By H. Calderwood. London and New York: Macmillan. 1879. Pp. 455. $4.

Botanical Text-Book: Practical Botany. By A. Gray, LL.D. New York: Ivison, Blakeman, Taylor & Co. 1879. Pp. 442.

Geological Survey of Ohio. Vol. III. Geology and Paleontology. Columbus, O.: Nevins & Myers. 1878. Pp. 958.

Scientific Grammar of the English Language. By W. Colegrove, A.M. New York: Authors' Publishing Company. 1879. Pp. 362.

Survey of the Northwestern Lakes and the Mississippi River. In charge of C. B. Comstock and H. M. Adams. Washington: Government Printing-Office. 1879. Pp. 62.

The Country Practitioner. Monthly. Beverly, N. J.: E. P. Townsend, M. D., editor. $2.50 per annum.

Thermo-dynamics. By H. G. Eddy. New York: Van Nostrand. 1879. Pp. 182.

The Position: A Thesis. By Cyrus the Elamite. Louisville, Ky.: R. R. Bolling & Co. 1879. Pp. 65.

Form of Seeds as a Factor in Natural Selection. By R. G. C. Stearne. From the "American Naturalist." Pp. 9.

American Nervousness. By G. M. Beard, M. D. From the Virginia "Medical Monthly." 1879. Pp. 24.

The Perihelia Crisis. By R. Mansill. Rock Island, Ill. 1879. Pp. 42. 50 cents.

Effects of Frost of Plants. By T. J. Burrell. Pp. 9.

Seed-Breeding. By G. L. Sturtevant, M. D. From "Report of Secretary of the Connecticut Board of Agriculture." Pp. 28.

Logical Basis of the High Potency Question. By S. Potter, M. D. From the "Hahnemannian Monthly." Pp. 25.

Report of Central Park Menagerie (1878). New York: Brown print. 1879. Pp. 30.

Life and Work of Joseph Henry. By F. L. Pope. From "Journal of the American Electrical Society." Pp. 31.

Meteoric Fire-Balls. By D. Kirkwood. From "Proceedings of the American Philosophical Society." Pp. 8.

New Jurassic Mammal. By O. C. Marsh. From "American Journal of Science and Arts." Pp. 2.

Geology of the Diamantiferous Region of the Province of Paraná, Brazil. By O. A. Derby. Pp. 7.

Distribution of Heat in the Spectra of Various Sources of Radiation. By W. W. Jacques. With Plates. Cambridge: University Press. Pp. 24.

"New York Herald" Weather Service (1877, 1878, 1879). Pp. 31.

POPULAR MISCELLANY.

Bodily Injuries from Falling Meteors.—In view of the estimate made by Mr. G. J. Stoney in the paper elsewhere published in the present number of the Monthly, the following observations by Professor H. Karsten, which we take from "Die Natur," can not fail to be interesting.

The accounts recently published, of the falling of sundry small meteorites in the vicinity of men or even upon their persons, have vividly recalled to my mind another instance, as I conceive, of this phenomenon. In this case a man was wounded in such a way as to lead the bystanders to conclude that he had been wounded by a pistol-ball, though the most thorough search failed to discover any evidence confirmatory of that opinion.

The reader will perhaps remember how, according to the "Cologne Zeitung," on August 29th of year before last, at half-past nine in the morning, a certain married couple living in the house No. 32 Neumarkt, in that city, were startled by a small stone falling through the open window into their room. "The wife ran and picked it up—a black-gray, prismatic stone of the size of a small bean; but, as it was red-hot and burned the tips of her fingers, she quickly dropped it again. Some minutes later the husband again took it up and found it to be still so hot that he could hardly hold it in his hand." This stone, which was immediately taken to the editor's office, was by all recognized as a meteorite.

Shortly before this, at Hanau, a boy was hit on the thumb in the open fields by a small, hot, falling stone; this, too, was supposed to be a meteorite. Unfortunately, it was never found.

At Schaffhausen, on the 2d of October, 1875, while a man was trundling a cart from the village of Beringen to Neuhausen, hence while going nearly due east, his right forearm was perforated from front to back as though by a musket-ball. The man was in the company of his brother and an acquaintance. At the moment of receiving the wound he heard a peculiar whirr as of a ball, but his companions say that they heard nothing. They all three searched high and low all around to discover the one who had fired the ball, but in vain, though the high-

way in which they were traveling ran straight through the open, level fields; neither was any one to be seen on the railway lying at no great distance to the right. Shortly after the occurrence the train from Neuhausen passed by. At some distance on the left are vineyards, where a few laborers were seen, but none of them had firearms, and even if they had they could not have sent a ball as far as the highway. It may be added that the wounded man is a peaceable fellow, having no enemies, so far as he knows. Besides, the missile—as is to be seen from the wound—came from the front, where no human being was to be seen on the broad, straight highway. The anterior wound was two inches inside of and two inches above the capitulum radii, and the posterior wound, which was only five millimetres in diameter, was two inches inside of and one and one third inch above the inner condyle of the ulna. The physician who attended to the case asked my opinion about this enigmatical occurrence; and, on my attributing it either to an air-gun or to a meteorite, he rejected both hypotheses. It could not have been an air-gun, he said, because no such instrument had ever been heard of in that locality; and because, even if such an instrument had been used, no one after discharging it could have concealed himself, owing to the nature of the ground, as already described. As for meteorites, no one had ever known of people being wounded by them. I was not prepared to prove my second hypothesis or to strengthen it by citing analogous instances, though authors had often recorded and described the falling of great stones in fields and through the roofs of human habitations, the bursting of falling stones in mid-air, and the scattering of the fragments. Still the hypothesis seemed to me to be not altogether groundless in the present instance, and it was strengthened by the known velocity of meteoric stones, which is on an average twelve times as great as that of a musket-ball. Then, too, the time of year and the direction of the projectile favor the opinion that the wound was inflicted by some small stray meteorite. Everybody attributed the wound to a ball from a revolver, because there was no other way to account for it. Had one of the two fellow travelers or one of the laborers in the distant vineyards been in possession of a revolver or other firearm, it would not have been easy for him to clear himself of the suspicion of having shot the man. On this ground, if not on account of its general interest, it is much to be desired that such occurrences should be investigated and published, to the end that, by bringing together and discussing the facts, light might be thrown on this interesting but as yet obscure subject.

Cold-Water Baths.—In some remarks on cold-water bathing in cold weather, the London "Lancet" points out the true use of such baths—which is to stimulate the organism to increased activity, and then shows how this effect is best obtained. A great mistake is made when any part of the body is immersed in cold water and left to part with its heat without any guarantee that the energy of heat-production so severely taxed can respond to the requirement. It may easily happen that the internal heat-production will be exhausted, and if that occurs harm has been done. The obvious principle of health preservation is to maintain the circulation in its integrity; and while the error of supposing that clothing can do more than keep in the heat generated within is avoided, it is not less needful to guard against the evil of depriving the body of the heat it has produced. The furnace should be supplied with suitable fuel, i. e., nutritious food; the machinery of heat-production, which takes place throughout the organism not in any one spot or center, should be kept in working order, and nothing conduces to this end more directly than the free use of the cold douche and the shower-bath; but the application ought to be restricted to a few seconds of time, and, unless the evidences of stimulation—redness and steaming of the surface—are rapidly produced, the effusion should be laid aside. The use of cold water in cold weather is a practice which must be governed by rules special to each individual case. Whether the practice recommended be that of plunging the feet in cold water before going to bed, to procure sleep—which the "Lancet" denounces as "a reckless prescription founded on a physiological fallacy"—or any other use of cold water, the only safe course is to seek the counsel

of a medical man conversant with the patient's peculiarities: particularly in the case of children should this precaution be observed.

Meteorological.—Professor Loomis continues his investigations of the development and phenomena of storms in the United States, in the July number of the "American Journal of Science." In this paper, the eleventh one of the series, it is shown that atmospheric disturbances during storms do not generally extend more than about a mile above the sea-level as they pass over New England. From observations made at the sea-level, as at Portland, simultaneously with observations at the summit of Mount Washington, it is found that during the passage of storms the usual system of circulating winds, does not in a majority of instances extend to a height of six thousand feet. The more violent the movement, however, the greater is the height attained by the disturbance. Another fact of interest is that the disturbance on the approach of a storm is felt at the surface sooner than at considerable elevations. Professor Loomis says that, "when during the progress of an area of low pressure the system of circulating winds reaches to the summit of Mount Washington, the change of wind to the east quarter usually begins at the surface stations eleven hours sooner than it does on the summit of that mountain." It thus appears that only in the lower portions of the atmosphere do the great storm movements occur, and they are first felt at or near the earth's surface.

Why is Music pleasurable?—Darwin, in "The Descent of Man," says of the problem, why musical tones in a certain order and rhythm give man and other animals pleasure, that it is at present insoluble. "We can no more give the reason than for the pleasantness of certain tastes and smells." But Mr. Xenos Clark, in the "American Naturalist," ingeniously essays a solution of this problem, and at the same time offers a theory of the origin of melody. "A musical sound," writes Mr. Clark, "is compound in its structure, being really a group of simple tones heard simultaneously. This group is composed of a ground-tone or fundamental, and a number of overtones, that decrease in intensity as they rise in pitch through a series of harmonic intervals. These intervals, the octave, fifth, fourth, and third, which thus occur in every musical sound we hear, are also at the basis of every human and, I hope to show, extra-human melody . . . . The thought at once arises that the peculiar, compound, harmonic structure of musical sounds has in some way impressed itself upon the auditory mechanism; so that melody, gradually growing under the guidance of the ear thus modified, has been molded into a musical form similar to that possessed by the group of harmonically related tones which we have seen to compose the sounds indicated. This seems very probable. For since each terminal nerve, of the thousands in the cochlea, responds to a given simple tone, the group of such tones forming a musical sound will excite a corresponding group of nerves, which will of course be related among themselves, as are the exciting tones among themselves; that is, they will be serially octaves, fifths, fourths, and thirds apart. Every nerve will therefore have always been stimulated in company with certain others, at harmonic intervals from it; and it is inevitable that the incessant and long-continued repetition of this coöperate activity should have resulted in some anatomical or functional bond; a pathway, as it were, leading from each member of the group to every other. *The progress of any melody will be easiest along this harmonic pathway, worn by the physical structure of sound.*" This would be the origin of melody, and at the same time would explain why musical tones in a certain order give man and other animals pleasure.

The Social Relations of the Future.—The views of Mr. Matthew Arnold on the tendencies of our modern social and political life are very well summed up in a recent number of the "Athenæum" as follows: The inevitable future Mr. Arnold sees to be *democracy:* the many are continually growing less and less disposed to admire, and the few, that is the aristocracy, are becoming less and less qualified to command and captivate. Now, this is not only a fact, but one we should have foreseen long ago, for it is only an example and as-

sertion of that principle of expansion which is a law of nature: in other words, it is natural that all classes and all persons should strive to be heard in matters of moment to the entire community. This being, then, the course which events must take, and which it is even desirable that they should take, we must prepare for the changes it will unavoidably bring about. This must be done in two practical ways: 1. By making the change easier, and this will be done by certain alterations in the laws of bequest and inheritance; and, 2. By making due provision for the new order of things by reforming middle-class education. The state (of which Mr. Arnold accepts Burke's definition, the nation in its corporate and collective character) is to found schools for the middle classes resembling those French *lycées* which have made the middle classes in France so superior to the same classes in England, rather than the "classical and commercial academies" whose advertisements crowd the newspaper columns; and the purpose to keep in view in the bestowal of that education is the awakening of a wider sympathy and a greater tolerance than have hitherto marked the English middle classes. They are to be delivered at once from "narrow Biblism" and from "immense *ennui*." For the rest, Mr. Arnold points out how democracy, instead of being, as it might be, the salvation of the race, may be the end of progress if, in the new conditions, the ideals of life and conduct are less high and less beautiful than of old, and if the arts and other refining influences not bearing immediately on practical life be suffered to fall into disuse and dishonor.

The Argan-Tree of Southwestern Marocco.—Dr. Hooker gives a full and very interesting account of this tree in his "Journal of a Tour in Marocco." It is found on a strip of land about forty miles wide which extends along the coast some two hundred miles. "It is absolutely unknown elsewhere in the world." This tree was first described about the year 1510, by Leo Africanus, who saw it in its native habitat. It is closely allied to the *Sideroxylon* (ironwood), a tropical genus. The wood is extremely hard, fine grained, of a yellow color, and apparently indestructible by insects. It is of slow growth, and occurs on sandy soils, and on barren hills, where irrigation is impossible. Not far from Mogador is a large specimen, probably three hundred years old. It measures twenty-six feet in girth. Three immense branches extend from the trunk at only three feet from the ground, one of which rests on the ground and measures eleven feet in circumference. The spread of the branches covers an area seventy feet across. The tree attains only a very moderate height. As the trees throw out branches near the ground, goats frequently climb them to obtain the oily fruit which they bear. Dr. Hooker observes that he had not been accustomed to consider the goat an arboreal quadruped. The oil extracted from the nuts is used by the natives for many domestic purposes, but has a rank and unpleasant flavor, not relished by those unaccustomed to it. About fifty tons is annually consumed. The argan-tree is a striking feature of the plains of Southwestern Marocco. It never forms a dense forest, but is distributed in clumps where few other trees are found.

What Modern Geography includes.—In a memorial addressed by the Council of the London Royal Geographical Society to the Vice-Chancellors of Oxford and Cambridge Universities, the scope and purpose of geographical purposes are defined in the following terms: By geography is meant a compendious treatment of all the prominent conditions of a country, such as its climate, configuration, minerals, plants, and animals, as well as its human inhabitants; the latter in respect not only to their race, but also to their present and past history, so far as it is intimately connected with the peculiarities of the land they inhabit. A scientific geographer does not confine himself to descriptions of separate localities, such as may be found in gazetteers, but he groups similar cases together and draws those generalizations from them to which the name of "Aspects of Nature" has been given. He studies the mutual balance and restraint of the various forms of vegetation and of animal life under different local conditions, and he gathers evidence from the geographical

conditions of the present time on the character of those which preceded and gave rise to them. Of the many classes of problems falling under these heads two are specified: The one deals with the reciprocal influence of man and his surroundings, showing on the one hand the influence of external nature on race, commercial development and sociology, and on the other the influence of man on nature, in the clearing of forests, cultivation and drainage of the soil, introduction of new plants and domestic animals, and the like. The other problem deals with the inferences that may be drawn from the present distribution of plants and animals in respect to the configuration of the surface of the earth in ancient times. Thus we see that the mutual relations of the different sciences is the subject of a science in itself, so that scientific geography may be defined as *the study of local correlations.*

What the Eyes see in reading.—On page 838 of our fourteenth volume we published some remarks by M. Javel on the impairment of eyesight caused by habitual protracted reading. M. Javel has since published some further observations on the mode in which the eye "takes in" the successive letters on a printed page. We are not to suppose, he says, that in reading a line one passes successively from the lower part of a letter to the upper part, then down the next letter, up the next, and so on, the vision describing a wavy line. The fixation takes place with extreme precision along a straight line, traversing the junction of the upper third of the letter with the lower two thirds. Why is this line not in the middle? Because characteristic parts of the letters are more frequently above than below, in the proportion of about seventy-five per cent. That this is so, we can see by applying on a line of typographic characters a sheet of paper covering the line in its lower two thirds, and leaving the upper third exposed. We can then read the letters almost as well as if they had not been concealed in greater part. But the case is very different if we cover the upper two thirds of the line; the lowest third alone does not furnish sufficient for recognition. The characteristic part of the letters, then, is chiefly in their upper portion. M. Javel next compares the ancient typographic characters with those of modern books, and maintains that the latter have too much uniformity, so that, taken in their upper parts alone, many of them may be confounded in reading. The old letters, on the other hand, had each a particular sign by which they could be easily distinguished. The Elzevirian *a*, for example, has no resemblance to *o*, the *r* could not be confounded with the *n*, as now, nor the *c* or *e* with *o*, the *b* with *h*, etc. This too great uniformity in the upper part of typographic characters should be corrected, since it is to that part we chiefly look in reading.

Professor Vaughan on the Origin of the Asteroids.—It is to the general features of the numerous small planets beyond Mars that we must look for a record of their past history. Though most liable to elude the search of the observers, asteroids of great orbital inclination to the ecliptic show already such numbers as to prove a stumbling-block to the usual methods of inquiry respecting the primitive condition of the planetary group. If, as Laplace supposes, they are parts of a ruptured solar ring, they could never deviate far from the plane of Jupiter's orbit by the attractive influence of other planets, and the greatness of the deviation as well as its independence of size excludes the idea of its arising from any mutual action exerted among themselves. The hypothesis of Olbers fails also to meet the difficulty. In the explosion of a single planet moving in the plane of the ecliptic, such an impulse as produced the great inclinations of the paths of Pallas, Euphrosyne, Gallia, Electra, or Artemis, would give cometary orbits to masses launched forth in opposite tangential directions, and cause many asteroids of such an origin to wander far beyond the zone between Mars and Jupiter. Yet the peculiarities in question are precisely such as may be expected in a group of bodies owing their birth to a collision of two planets not very unequal in size or mass. Such an event would be possible when by long disturbance the orbits of both become too eccentric for safety, and when the aphelion of one was in conjunction with the perihelion of the other and near the intersection of their planes. Supposing both or-

bits to touch at the colliding point, the resulting fragments would be driven forth in a plane perpendicular to the course of their common center of gravity. If the velocity from the impulse were thirty-two per cent. of that required for describing a circle, they would be constrained to move in ellipses varying in eccentricity between ·32 and ·1024; and about seven eighths of the known asteroids conform to this limitation in the form of their orbits. Had the motion of both planets been merely progressive and coincident with the ecliptic, the orbital inclination for the fragmentary group would vary from 0 to about 19°, yet the range would pass many degrees beyond this limit through the influence of rotation in the great spheres in causing their matter to fly more rapidly into space in a polar direction in the early stage of the collision. Yet this rotational movement would prevent the eccentricities of the numerous orbits from assuming the proportions which might be expected if the line of motion of the colliding orbs did not pass through their centers as in the supposed case.

There is another clew to the cosmical history of the region between Mars and Jupiter. The orbits of Saturn's moons show a near conformity to geometrical progression, and, taking the common rates at 1·30756, the following table gives the empirical as compared with the actual distances in equatorial semi-diameters of the primary:

Mimas..................	3·3607	3·3607
Encaladus..............	4·3933	4·3125
Tethys..................	5·7483	5·3396
Dione...................	7·5182	6·8398
Rhea....................	9·8325	9·5528
....	12·8600	.....
....	16·8190	......
Titan...................	21·9972	22·1450
Hyperion..............	28·7690	26·7834
....	37·6250	....
....	49·2150	....
Japetus................	64·3590	64·3590

It appears from this table that two consecutive satellites are missing in each of the chasms in the Saturnian family, and this evidence of their transformation into asteroids seems more reasonable on considering the disturbing influences of Titan and Japetus on their planetary neighbors. The array of the satellites near Saturn would also lead to the belief of more worlds than one near the sun, and the vain search for Vulcan would render more probable the existence of an asteroidal group within the orbit of Mercury.

Listening to the Pulse.—We take from the "Lancet" an account of a new instrument—the sphygmophone—invented by Dr. Richardson, of London, and which transmutes the movements of the arterial pulse into loud telephonic sounds. The needle of a Pond's sphygmograph is made to traverse a metal or carbon plate, which is connected with the zinc pole of a Leclanché cell. To the metal stem of the sphygmograph is then attached one terminal of a telephone, the other terminal being connected with the opposite pole of the battery. When the whole is ready the sphygmograph is brought into use as if a tracing were about to be taken, and when the pulsation of the needle from the pulse-strokes is secured, the needle, which previously was held back, is thrown over, so as to make its point just touch the metal or carbon plate, and to traverse the plate to and fro with each pulsation. In so moving, three sounds, one long and two short, are given out from the telephone, which sounds correspond with the first, second, and third events of sphygmographic reading. In fact, the pulse talks telephonically, and so loudly, that when two cells are used the sounds can be heard by a large audience.

The Audiometer. — "Audimeter," or "audiometer," is the name given to an instrument invented by Professor Hughes, with the aid of which a person's power of hearing sounds can be very accurately measured. It is formed of a small battery of one or two Leclanché cells, a new microphonic key, two fixed primary coils, a graduated insulated bar, to which at each end one of the fixed coils is attached, a secondary induction coil, which moves along the graduated bar, and a telephone, the terminals of which are connected with the terminals of the induction coil. The principle of the audiometer is based on the physical fact that when the battery is in action, and a current is passing through the two primary coils, the secondary coil on the bar becomes charged by induction whenever it is brought near to either of the primary coils; but, when it is brought to the precise

center between the primary coils, there is a neutral point or electrical balance, where the electrical phenomena from induction cease to be manifested.

In the "Lancet" we find an account of a meeting of the London Royal Society, at which Dr. Richardson demonstrated the action of the audiometer. He was assisted in this demonstration by Professor Hughes, who, by placing a microphonic key between the battery and one of the primary coils, and by attaching the terminals of the induction coil to the telephone, was able to make the telephone produce sounds whenever he brought the induction coil near to one of the primary coils, and moved the microphonic key so as to make it play on a fine needle suspended in the circuit. "When the induction coil is close to one of the primary coils," says the "Lancet," "the noise is very loud, but as the coil is moved toward the center of the bar the noise diminishes, until it ceases at the center altogether. The scale on the bar is graduated into two hundred degrees, representing units of sound from 200 to zero. At 200 all who can hear at all, can hear the vibration of the drum in the telephone. At zero no one can hear, while between the two points there are two hundred gradations of sound, from the highest down to zero."

A Dog's Affection.—The following narrative is from "Chambers's Journal." Some time ago the late Mr. H—— possessed a collie shepherd-dog, which was very clever at its duty until it had a litter, one of which was spared to it. After this all the poor animal's affections seemed to be centered in her puppy, for she refused, or did most unwillingly, the work she had to do, which so vexed her master that he cruelly drowned the puppy before the mother's eyes, covering the bucket in which he left the body with a sack. He then went round the fields, followed by the old dog, who from that moment resumed her former usefulness. On the master's return in the evening, he bethought himself of the bucket and went to fetch it to empty the contents into a hole which he had made in the manure-heap; he found the bucket covered as he had left it, but on pouring out the contents there was nothing but water. He questioned his wife and other inmates of his house, but they knew nothing about it. The next morning Mrs. H—— was struck with the piteous expression of the poor animal's face, and said to her, "Scottie, tell me where you have taken your puppy." The dog immediately ran off a distance of one hundred yards to the kitchen garden, jumped the fence, and went direct to the farther end of the inclosure to a spot situated between two rows of beans; there, where the earth had apparently been recently moved, she sat, and as it were, wept. Mrs. H—— went again into the house, and without mentioning what had occurred, said to her niece, "Ask Scottie what she has done with her puppy." The question was put, and again the poor creature went through the same performance. These circumstances were mentioned to Mr. H——, who pooh-poohed the idea of there being anything out of the common; but to satisfy his wife he went to the spot and dug down a distance of three feet, and there, sure enough, had the faithful, fond mother buried her little one!

Sympathy in an Ants' Nest.—According to Sir John Lubbock's observations, ants belonging to the same nest never quarrel among themselves; he has never seen any evidence of ill-temper in any of his nests. Again, ants appear to show great kindness to inmates of their own nests which happen to be in straits. In one of Sir John's nests of *Formica fusca* was a poor ant which had come into the world without antennæ. Never having previously met with such a case, he watched her with great interest, but she never appeared to leave the nest. At length one day he found her wandering about in an aimless way, apparently not knowing whither to turn. After a while she fell in with some specimens of *Lasius flavus*, who directly attacked her. He rescued her, but she was evidently badly wounded, and lay helpless on the ground. After some time another *F. fusca* from her nest came that way, examined the poor sufferer carefully, then picked her up and carried her away into the nest. It would have been difficult, Sir John Lubbock thinks, for any one who witnessed this scene to have denied to the ant the possession of humane feelings.

Fossil Rhinoceros in Siberia.—In a communication to "La Nature," A. Hoffmann, of Moscow, announces the discovery, in Siberia, of the head of a rhinoceros (*Rhinocerus tichorhinus*), which still retains, in a wonderful state of preservation, nearly all its covering of flesh. "This head," he writes, "was found near a small stream, called the Balantaï, a tributary of the Yany, at the distance of some 200 versts from the city of Vorshvianska. M. Gorokoff, to whom we are indebted for this discovery, made haste to communicate with the Imperial Geographical Society of St. Petersburg. A member of that Society, M. Tshersky, to whom the head was submitted for examination, says that it must have belonged to a young animal, for some of the teeth had not as yet quite come out from their alveoli. The entire head is covered with a strong tissue, hardened by time; but one side of it is badly injured. Here the flesh is in part decayed, and crumbles away. A portion of the skull is bare, and we can see the dried muscles and veins; also, a portion of the spinal marrow, the latter having dropped out of the passage through the second cervical vertebra. This curious fossil head retains in perfect preservation the muzzle, the lips, the ears, the hair of half of the left side, a good part of the forehead, and on the right side the upper portion of the neck, and several other parts. Further, we notice the places for two horns."

Drilling Rocks by Electricity.—M. Gaston Planté suggests a novel use for electricity, namely, as a borer of rocks, taking the place of the black diamond. "We have seen," he writes in a volume recently published, "that one of the electrodes which conveys a current of a certain electromotive force, on being put in contact with glass in presence of a saline solution, acts as a graver or diamond in cutting furrows on the surface of the glass, plowing it even deeply. Rock-crystal can also be attacked, despite its hardness, by the same method, and, if it does not yield regularly, it at last bursts into pieces under the action of the electrode, and ends by breaking up. In America black diamonds are employed in rock-drilling for wells and mines. Could these expensive tools not be replaced by the action of the electric current in conditions analogous to those which have been described, and the perforation of rocks be performed by electricity? Electrodes of platinum would not be necessary, for it is not the metal of the electrode which alters, but the silicious matter in presence of the saline solution. Metallic points or studs conveniently distributed at the end of the drill and put in rotation, would direct the electric discharge to the rock, which it would pulverize, as in the case of the diamond drill. The recent advances in the production of electricity by mechanical means would facilitate this application."

Mr. Gladstone on Natural History Studies.—Mr. Gladstone, in addressing the pupils of a Nonconformist school at Finchley, England, advocated a more important place in our systems of education for natural history. "Natural history," he said, "is a continual lesson—a lesson at once easy and profound—of the wisdom and beneficence of Providence; a continual confirmation of belief, when you find the wonderful hand of that Workman descending to the smallest object with the same care with which he mounts to the greatest. The religious use of natural history is one that all must delight in. Again, learning is an admirable thing, but it does not always make itself agreeable at the first introduction. But it certainly is a marked advantage in the study of natural history that it leads you on by the hand—it inveigles you, so to speak, into learning what is good and what is useful. Many a one might have his mind first opened by the attractions of natural history, and, once opened, it might perhaps be capable of applying itself beneficially to harder and more repulsive studies. Natural history, too, is one of the best and most efficient means of educating the senses. It may, perhaps, be suggested that the senses are educated well enough already, and claim quite a large enough portion of our existence. That, of course, is perfectly true so far as the grosser forms of enjoyment are concerned; but so far as the senses are connected with the acquisition of knowledge, they are very indifferently educated indeed. The habit of minute, careful, and accurate observation, which is inseparable from such a study as

that of natural history, gives that power of accurate deduction which is invaluable in the pursuit of every branch of knowledge. We all know, I may add, how much has been done in the researches of our time by applying the principle of comparison—comparison, for example, of the structure of living bodies as the basis of modern biology, the comparison of the structures of languages as the basis of philology. Depend upon it, then, that the observation and analogy which natural history is continually suggesting, as it is valuable for the purposes of science, so it has a lighter but a most graceful and civilizing use in supplying those analogies taken from the seen world and applicable to the unseen, assisting in giving to every work of the mind that grace and beauty which is just as appropriate and desirable, though it may not be so indispensable to it, as are the higher qualities of solidity and truth."

How the "Goat-Suckers" came by their Name.—Mr. A. R. Wallace calls attention to an interesting observation made by Charles Waterton, which throws some light on the origin of one of the superstitions of natural history. Ever since the time of Aristotle, at least, the belief has prevailed that the bird known as the "goat-sucker" (*Caprimulgus*) actually sucks goats or cows. According to Pliny, the goat-sucker "enters the fold and flies to the udders of the goats in order to suck the milk." The fact that the birds "fly to the udders" of the animals is confirmed by Waterton, but at the same time he shows how erroneous is the inference that they suck the milk. "I am fully persuaded," writes that ingenious observer, "that these innocent little birds never suck the herds, for when they approach them, *and jump up at their udders*, it is to catch the flies and insects there. When the moon shone bright I would frequently go and stand within three yards of a cow, *and distinctly see the caprimulgus catch the flies on its udder*." In another place he writes: "When the moon shines bright you may have a fair opportunity of examining the goat-sucker. You will see it close by the cows, goats, and sheep, jumping up every now and then under their bellies. Approach a little nearer—see how the nocturnal flies are tormenting the herd, and with what dexterity he springs up and catches them, as fast as they alight on the belly, legs, and udders of the animals. Observe how quiet they stand, and how sensible they seem of his good offices, for they neither strike him nor hit him with their tails, nor tread on him, nor try to drive him away as an uncivil intruder."

Geographical Distribution of Bats.—At a meeting of the "Scientific Societies of the Departments," lately held at Paris, a report of which is given in "La Nature," Dr. Trouessart, under the title of "Geographical Distribution of the Bats" (*Cheiroptera*), read a paper, of which the following is a summary: There are certain species of bats which pass the winter in a state of torpor in caverns or in abandoned quarries—for example, the horseshoe bat—or in the hollows of trees, under the roof-timbers of houses, or in crannies in the walls—as the *Pipistrella*, so common in cities, which, awakening during very mild winters, is sometimes seen flitting about in January. But it is an error to suppose that all bats hibernate. Many *Cheiroptera* migrate after the manner of birds, and this fact accounts for the reduction of the number of species from eight hundred to four hundred, as distinctions of species had been set up merely on the ground of the great distance between localities. Many species of bats seen in France are migratory, and are found there only in the summer months, having come in pursuit of the insects on which they subsist. Of twenty-five species occurring in Europe, at least twenty-two are found also in eastern Asia. Bats possess considerable power of flight. The flying fox (*Pteropus rubricollis*) of the tropical parts of the Old World can at one flight compass a distance of thirty leagues. This vigorous power of flight explains the presence of *Cheiroptera* in Australia, where they are the only native *Monodelphs*, as also in the islands of Polynesia and in New Zealand, a country rich in its avifauna, but which, with the exception of several species of bats, possesses no mammals save those purposely introduced by man, and the rats and mice brought by ships. Of the six families of the order *Cheiroptera*, the *Phyllostomata* are exclu-

sively American; the *Emballonura* have only one representative in Europe—a *Molossus* found on the shores of the Mediterranean, and which visits Switzerland in summer; two species of *Rhinolophus* (the great and the less horseshoe bat) are found in Great Britain, and the former of these species is distributed as far eastward as Japan. The *Vespertilios* constitute a truly cosmopolitan family, extending in latitude from the border of the Arctic region down to the Strait of Magelhaens. The *Serotina* occurs throughout Europe, in Asia, and in Africa down to the Gaboon; and one race of this species is found in America as far south as Guatemala. But in those parts of both hemispheres which lie farther south, the *Serotina* is succeeded by nearly allied species of the same subgenus *Vesperus*. Of fossil *Cheiroptera* we have but very few. The gypsum strata of Montmartre have yielded to science *Vesperugo parisiensis*, which is closely analogous to, if not identical with, the *Serotina* of France. Again, among the Eocene *Cheiroptera* of North America described by Marsh occurs a *Serotina*, resembling the race now existing in the same region. And as the power of flight possessed by the *Cheiroptera* accounts for their geographical distribution (which is analogous to that of birds), so, too, it affords a probable explanation of the inconsiderable changes which the order has undergone since Tertiary times. Undoubtedly it is through this power of flight that they were enabled to escape amid the geological cataclysms which long ago annihilated the giant land mammals which were their contemporaries in the Eocene.

Ancient American Pottery.—A very remarkable collection of ancient American pottery is now on exhibition at No. 77 Maiden Lane, New York. It consists of about twelve hundred pieces, and is the fruit of explorations conducted by Mr. J. A. McNiel in an ancient cemetery in Chiriqui, Panama. The graves in which these articles of pottery were found lie scattered along the Pacific slope of the foot-hills of Mount Chiriqui, and the "cemetery" covers thousands of square miles. The graves do not appear to have been disposed according to any definite plan, nor do they lie with reference to any one point of the compass. They are found at varying depths, sometimes being as much as fifteen feet below the surface, and sometimes not more than two or three feet. Many of them appear to have been opened again and again for successive interments. They are walled up on the sides and at the ends with large round stones, which are plainly water-worn, and must have been brought from river-beds at a considerable distance. The graves are covered with flat stones, some of them weighing three hundred pounds. These stones do not belong to the local formations, and can only have been procured from situations several miles distant up the mountain-side. As there are no indications on the surface as to where the graves are hid, they are discovered by thrusting an iron rod into the earth till it strikes a stone. The articles of pottery found in these graves are principally jars and tripods, with a few small objects, toys, and whistles, and certain thin, flat disks pierced with a hole in the center, that may have served as wheels of toy carts.

Adulteration of Drugs.—In France all pharmacies are subject to inspection with regard to their general management, and more particularly to their practice in dispensing poisonous substances, and to the purity of the drugs and medicines kept on sale. But even in that country unscrupulous pharmacists are found who palm off upon the public adulterated drugs. Indeed, so common is this practice that careful physicians, whenever they prescribe any medicine that is difficult to prepare or specially costly, are wont to advise their patients to have the prescriptions made up only by pharmacists of approved integrity. At a meeting of one of the medical societies of Paris the following instance was given of the ill effects of using adulterated medicines: A physician having been called to attend a girl suffering from a violent attack of fever, prescribed a strong dose of quinine sulphate, hoping thus to prevent, or at least to mitigate, the second attack. But this second attack was worse than the first, and the patient's condition became very serious. Seeing that the quinine was without effect, the physician procured some of it for analysis, and procured at a reputable pharmacy another dose of the drug. This having been administered to the patient, the third attack

of the fever was far less violent than the two preceding. The analysis showed that the suspected quinine sulphate was strongly adulterated with salicine.

NOTES.

LARGE numbers of *Trichina spiralis* have been detected in cured meats imported into Alsace from America. In Switzerland, too, the discovery has been made that American hams are full of the trichina, and a government commission has been appointed to decide upon the precautionary measures to be taken. The cantonal authorities are recommended to warn the people against the use of American hams, especially in the half-raw state, and to arm the police with discretionary powers over the sale of the article.

ON the 2d of June the Paris Academy of Sciences elected Professor Huxley to be a corresponding member of the Academy for the section of anatomy and zoölogy. Professor Huxley received 41 votes out of a total of 49; Agassiz received 5 votes, Bischoff 1, and there were two blank ballots.

A NEW method of excavating for the erection of telegraph-poles has been devised and put to the test at Titusville, Pennsylvania. A man drives a crowbar into the ground to the depth of four or five feet, and into the hole so made drops a four-ounce cartridge of so-called "electric powder." The fuse having been lighted, the man proceeds to the site of the next pole. In the mean time a dull sound is heard, and a hole about the diameter of a flour-barrel, and four or five feet deep, has been made by the exploding cartridge.

To meet the convenience of students, and thus remove the sole objection in the minds of professors to the extended use of an admirable series of text-books, Macmillan & Co., the publishers of the well-known "Clarendon Press Series of Educational Works," issued under the direction of the delegates of Oxford University, have in preparation a new nett catalogue of those works, as well as of their own educational works, which will be ready early in the fall.

THE utilization of bamboo for paper-making is advocated by a writer in the "Journal of the Society of Arts," who pronounces it far superior for that purpose to esparto-grass. Then, too, it can be produced at less cost than esparto. By utilizing the bamboo spontaneously produced in India, or, better still, by cultivating the plant there, an unfailing supply of the fiber might be produced.

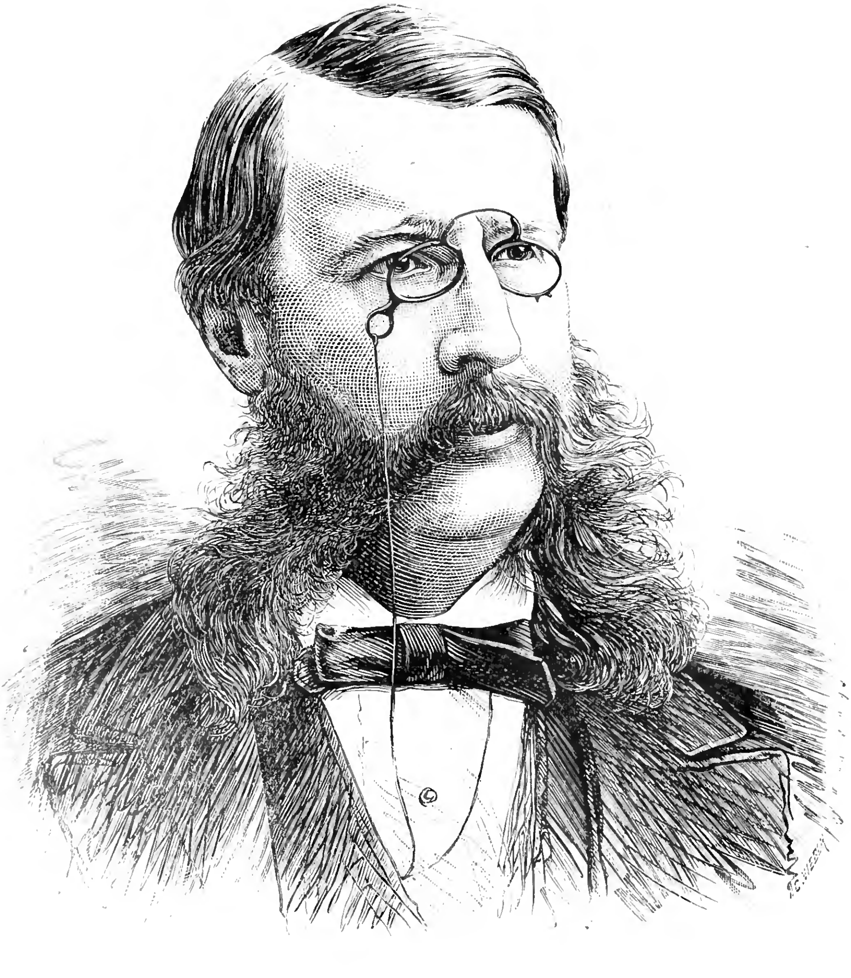
MR. W. MATTIEU WILLIAMS, who for more than thirty years has closely studied the subject of the electric light and noted every new development, does not hesitate to affirm that "although as a scientific achievement the electric light is a splendid success, its practical application to all purposes where cost is a matter of serious consideration is a complete and hopeless failure, *and must of necessity continue to be so!*"

THE amount of labor performed by bees in collecting honey may be seen from certain calculations made by Mr. Andrew Wilson. He finds that 125 heads of clover yield approximately one gramme of sugar (about $15\frac{1}{2}$ grains), and that 125,000 heads yield one kilogramme (2·2 pounds). Now, as each head of clover contains about 60 florets, it follows that the bees must suck 7,500,000 distinct florets in order to obtain $2\frac{1}{5}$ pounds of sugar. And as honey roughly may be said to contain 75 per cent. of sugar, we have one kilogramme, equivalent to 5,600,000 flowers in round numbers, or say 2,500,000 visits for one pound of honey.

THE custom of persons bearing two "Christian names" is of comparatively recent origin in England. An author, who has had occasion to search many volumes of old country records, and who has seen "many thousands and tens of thousands of proper names belonging to men of all ranks and degrees," says that in no instance, down to the end of the reign of Anne, has he noticed any person having more than one Christian name. The first instance which occurs in the county records was in 1717, when Sir Coplestone Warwick Bainfield appears as a justice. The first instances which the same author has met in any other place are those of Henry Frederick, Earl of Arundel, born 1608, and Sir Henry Frederick Thynne, created a baronet in 1641. Both of these appear to have been named after the eldest son of James I., who was born in Scotland. William III., who was a Dutchman, was the first King of England who bore two Christian names.

PROFESSOR STOKES, of the University of Cambridge, England, has been elected a corresponding member of the Paris Academy of Sciences. The German Emperor has also conferred upon him the decoration of the order "Pour le Mérite."

DR. WINNECKE, of Strasburg, has discovered a record of observations made in 1580, or at least thirty years before the invention of the telescope, in which the places of eleven stars of the Pleiades are given. On comparing these with modern observations, it appears that the places were determined with a probable error of only 2′; hence there can be little doubt that all these stars were seen by the naked eye.



GEORGE F. BARKER.

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SPIRITUALISM AS A SCIENTIFIC QUESTION.

AN OPEN LETTER TO PROFESSOR HERMANN ULRICI, OF HALLE,

By Professor WILHELM WUNDT,

OF THE UNIVERSITY OF LEIPSIC.

TRANSLATED FROM THE GERMAN BY EDWIN D. MEAD.*

RESPECTED SIR: In the latest number of your "Zeitschrift für Philosophie und philosophische Kritik" I have read a paper from your valued pen, in which you embody a detailed discussion of the spiritualistic phenomena observed here in Leipsic in the presence of the American medium, Mr. Henry Slade. You remark that, according to your conviction, the reality of the facts attested by eminent men of science can no longer be doubted, and that the so-called spiritualism has thus become a scientific question of the highest importance. I should have no occasion to enter upon a discussion of this view of yours, except for the fact that in connection with references to certain of my colleagues in the course of your article, my own name is mentioned in a way which makes it desirable for me to remove every doubt, which you and your readers may have, as to my attitude toward the "scientific question" which you have raised.

You remark that there were present at the *séances* held with Mr. Slade in Leipsic, besides those scientific men who became convinced of the actuality of the spiritualistic phenomena, certain other members

* Translator's Note.—To most regular readers of "The Popular Science Monthly" this letter will be its own sufficient explanation, yet an introductory word may not be superfluous. Spiritualism in Germany, as in England, presents certain phenomena almost precisely opposite to what is seen in America. With us, while the belief has obtained a great popular following, affecting almost all classes of society, becoming a kind of religion as it were, it has not succeeded in making converts of really scientific men, numbering almost no eminent scholars in its ranks—being simply neglected, for the most part, by

of the university, who did not appear to share this conviction. These, among whom you name myself, are of course perfectly free to believe or disbelieve as they please, but it is their duty, as representatives of science, "to state publicly what they saw, and why they doubt the objective reality of what they saw—why they feel compelled to assume jugglery, deceit, or illusion." You add that there remains to these deniers and doubters only the alternative, "either to acknowledge by their silence that there is nothing upon which they are able to base their doubts—therefore, that they simply *will* not believe what is perfectly attested—or to show how it was possible to deceive these men (and many others of unquestionable credibility) in so remarkable a manner."

I feel that I must not neglect so energetic a challenge, and you will permit me not only to make my explanations publicly, according to your wish, but also to address them to yourself. Your article, as I gladly acknowledge, has this advantage over the publications of

whatever properly calls itself science. In England, on the contrary, as is well known, while being no such widespread movement as in America, spiritualism has, during recent years, engaged the earnest attention of prominent scientific circles, has gained many converts of high scientific reputation, and drawn forth the most important contributions to the literature of the subject which exist. The case in Germany is very similar. The principal centers of interest in the subject have been the universities, and, above all, the University of Leipsic, and the principal participants in the investigations and the discussions have been eminent professors. The excitement recently has centered in the *séances* of Mr. Slade, who passed several months in Leipsic and Berlin after his ejection from England, two or three years ago. The result of these *séances* was the conversion or half conversion to spiritualism of several well-known Leipsic professors. Professor I. H. Fichte, now in his eighty-third year, has also recently confessed his faith, pronouncing the Slade phenomena to be "decisive for the cause of spiritualism in Germany." But most surprising of all, perhaps, has been the publication in the last number of the "Zeitschrift für Philosophie und philosophische Kritik," of an article by Professor Ulrici, of Halle, in which he declares his persuasion of the truth of the spiritualistic theory, likewise on the strength of the observations reported by the Leipsic professors—an article the general scope of which is made plain by Professor Wundt's references. To this article Professor Wundt, who has watched the whole movement with critical interest, and who indeed participated in the Slade experiments, deemed it his duty to reply, and he has done so in the form of the letter before us. To scientific men Professor Wundt needs no introduction. He is the principal lecturer in philosophy in the University of Leipsic, and perhaps the most eminent psychologist in Germany, a man of acute thought and well-balanced judgment, distinguished even among German scholars for the breadth and accuracy of his knowledge. It is not too much to say that the reputation and character of no living German thinker could give greater weight to any words on a subject like this. His letter has been immediately recognized in Germany as containing the most reasonable words which have yet been spoken on those phases of the subject to which it confines itself, and it will have a powerful effect in calling back many confused minds to soberness and sense. Professor Wundt believes that scientific men have no longer a right simply to neglect a movement which has become so widespread, which is the occasion of so much perplexity among the people at large, and which is so unquestionably mischievous. It is to be hoped that his words will not fail of their effect in America also, where the intellectual and moral disorders which he declares to be the logical and necessary results of opinions like those discussed are already so apparent and alarming.

similar character, which have heretofore come to my knowledge, that it not only describes certain especially striking instances of the phenomena in question, but also considers the scientific and particularly the philosophical consequences, which must be drawn from the same, as soon as we should determine to acknowledge their reality. I remark that here and in the following pages I use the word reality in the sense which it has in your discussion, excluding from it only the production of the phenomena in a fraudulent manner. For merely subjective phantasms of the observers, these phenomena, as you justly remark, can not be held ; their objectivity and reality in the ordinary sense of the word will in fact be questioned by no man, who may even have read only your short description. I must also agree with your assertion that these facts in and for themselves, their reality presupposed, are of a subordinate importance, compared with the consequences which follow them for our general view of the world. Whether, through conditions unknown to us, tables are occasionally lifted, accordions played, and bed-screens torn, or ghostly hands and feet appear—all this alone is quite indifferent, so long as things of the sort appear in a harmless form, as we may expect from previous observations, a form which clearly gives no fear of deeper disturbance of general natural laws. The more important, on the contrary, would be the philosophical consequences to which the reality of the spiritualistic phenomena would force us. I regard it, therefore, as a real service of your essay, that it not only points out these consequences in general, but that it also seeks to develop, by hints at least, the more particular conceptions which have been suggested to you, concerning the conditions of the phenomena in question, as well as their connection with the general order of the world, and their ethical and religious significance. You have thereby thrown light upon the subject from a side which appears to me more than all others worthy of attention.

I.

Before entering more particularly upon this most original and important part of your essay I am compelled to answer your question concerning my own participation in spiritualistic observations and in regard to the convictions I have gained from them. Permit me, at the same time, by way of preface, a few remarks concerning my attitude toward such phenomena as I have not myself observed, but know only from the statements of others.

You, respected sir, sustain precisely the same relation to all of the so-called "manifestations" which I sustain to a great part of them : your knowledge is based upon the reports of credible witnesses. Therefore you found yourself until recently in the position of a distant, unconcerned spectator. You have chosen to give up this character. You have not only come forward with the greatest energy in favor of the reality of the manifestations, but you also urge others, who would pre-

fer the part of unconcerned spectators, which you now disdain, to publicly confess their belief or unbelief. What impels you to this, as I must call it, remarkable proceeding? The phenomena in question—so you answer—have been observed by scientific men of acknowledged eminence, whose credibility can not be questioned; these men have pronounced them real, therefore their reality is not to be doubted. Your acceptance is, in a word, based upon *authority*. Before I come to the point, permit me two general questions, which I must indeed answer myself, but which I still hope to answer in a way to which you can make no material objection. The first question is, What are the characterizing marks of a scientific authority? The second, What are the limits of the influence upon our own knowledge which we may grant to authority?

What are the characterizing marks of a scientific authority? You, of course, immediately admit that scientific authority is not a property which could be set down in the description of a person. You also agree with me that a person, who passes for authority in some particular science, can not transfer this quality at his pleasure to other provinces. The apocalyptic studies of Isaac Newton were not saved from quick forgetfulness by the authority of the discoverer of gravitation, and the high esteem which Ernst von Baer enjoys as a naturalist scarcely serves as a bill of protection for his Homeric investigations. It is quite true that scientific employment in itself, regardless of the object with which it is concerned, begets that purely theoretical interest in the truth which makes absolute truthfulness of statement in scientific questions a conscientious duty. I should believe, indeed, that only scientific occupation can produce absolute trustworthiness in theoretical questions, because it alone makes a correct estimate of such questions possible. That in this regard the authorities whom you name have, as well on account of their high scientific position as on account of their universally acknowledged personal character, a credibility above every doubt, is a matter of course. But the highest degree of credibility is not sufficient to make any man a scientific authority; there is requisite to this a special professional and in most cases indeed a technical training, which must have approved itself by superior accomplishments in the province concerned. He who has not acquired this professional and technical culture by long years of severe labor is neither capable of achieving anything himself nor of judging the works of others.

You will probably reply to me here that the authorities to whom you appeal are distinguished naturalists, and it is with natural phenomena that the present case has to do. Unhappily, however, I must gainsay you in this; I can not admit that we here have to do with natural phenomena, to whose critical examination naturalists as such, whatever department of natural science they may have been engaged in, are in any way competent. I go still further, indeed, and maintain

that these phenomena are so different from the common province of the naturalist's observations, that they present to him especial difficulties, which plainly exist for others in a less degree.

All the methods of natural science rest upon the presupposition of an unchangeable order of occurrence, which presupposition involves the other, that everywhere, where the same conditions are given, the results must also agree. The naturalist, therefore, proceeds in his observations with unshakable confidence in the positiveness of his objects. Nature can not deceive him; there rules in nature neither freak nor accident. You will admit that we can not speak of a regularity of this sort in the domain of spiritualistic phenomena; on the contrary, the most conspicuous characteristic of these lies precisely in the fact that in their presence the laws of nature seem to be abrogated. But, even considered purely in themselves, they show no trace of an orderly connection or coherence. Even he who may have the hope that such an order will perhaps some day be discovered, can not deny that hitherto all hopes of this sort have been shipwrecked, that spiritualistic observation and natural science stand directly opposed to each other. As little can you deny, on the other hand, that that absolute confidence in the positiveness of the object (truthfulness of the medium) would not be in place in a province where the cardinal question, with which we first of all have to do, is precisely whether the phenomena possess reality or whether they rest upon deception.

Nevertheless I find in the observations which you report tolerably clear indications that the eminent naturalists, who deemed the medium Slade worthy of their investigation, transferred a portion of that confidence, which they justly bring to the ordinary objects of their observation, to this extraordinary object also. You report, for instance, the influences exerted by Mr. Slade upon the movements of a magnetic needle. It appears from your account that the medium was prepared for this experiment, similar experiments having been instituted in Berlin, at the instance of a scientific man there. The phenomena themselves are precisely the same as can be produced by a man provided with a strong magnet. You will not deny that such experiments possess convincing power only for him who is convinced of the correctness of the presupposition of the absolute trustworthiness of the investigated object, i. e., the medium. Now, that the eminent physicists who observed this remarkable phenomenon were chiefly chained by the reversal of the Ampèrian and Weberian molecular currents, which occurred under such unusual influences, is perfectly intelligible; a practical jurist would probably have been not so astonished, but, less accustomed to believe in the trustworthiness of the objects of his investigation, he would scarcely have neglected to examine the coat-sleeves of the medium, with reference to his magnetic powers.

I can not, therefore, respected sir, acknowledge the authorities in

natural science so highly valued by you and by me, as authorities in this province. In order to be able to speak with authority concerning any phenomena, one must possess a thorough critical knowledge of the same. Authorities in the present case, therefore, are only such persons as either possess mediumistic powers or, without claiming to be bearers of such properties, are able to produce phenomena of the same nature. As an authority I would therefore acknowledge Mr. Slade, if he possessed scientific credibility, and also by all means Herr Bellaihini, prestidigitateur in Berlin, who, as is well known, has declared in favor of Mr. Slade, if I could premise in his case that he had a conception of the scientific scope of this question. The only person of whom this is true, and who, at the same time, has successfully imitated many of the Slade experiments, is Dr. Christiani, assistant in the Physiological Institute in Berlin. Dr. Christiani, however, declares his experiments to be mere pieces of jugglery. Now, Herr Christiani is certainly not able to imitate all of Mr. Slade's experiments; but he only professes to be an amateur in a field which Mr. Slade cultivates professionally.

I come to my second question: *What influence may we concede to outside authority upon our own knowledge?* In the immensely preponderant majority of the things which we hold for certain, we all follow the authority of other men; we know only a proportionally small number of facts from our own investigation. Yet all that we owe to foreign authority passes for the more certain the more it agrees with our observation. If a new fact is communicated to us, the investigation of which we are not ourselves in a position to control, then, at least according to the principles hitherto authoritative in science, *two* criteria must be satisfied, if we are to hold the same to be true: First, it must be confirmed by a credible person, who is master of the field concerned; and, secondly, it must not contradict other established facts. Now, you will probably urge here that this second criterion is an exceedingly fluctuating one. Indeed, various spiritualistic authors have not failed to adduce a multitude of instances from the history of science, in which a fact was at first rejected as false or even impossible, and was yet at last proved to be true. But I beg to call your attention to the fact that, in all these instances, the *tertium comparationis* with the case before us consists simply and solely in the fact that something was asserted by some scholars and denied by others. This case still occurs of course repeatedly, and the controversy is always decided in favor of those whose observations stand in contradiction with no other established fact. Usually, indeed, the best passport which a discoverer gives to his new observation consists precisely in his indication of its agreement with other facts. I have looked in vain through the whole history of science for a case in which a scientific authority came forward with the assertion of having discovered a new fact, at the same time adding to this assertion the assurance that

all natural laws were overthrown by the fact, and that in the fact itself no kind of law or order was to be perceived. This case lies before us here. The laws of gravitation, of electricity, of light, and of heat are altogether, as we are assured, of a purely hypothetical validity; they have authority as long as the inexplicable spiritualistic something does not cross them. In this something itself, however, there is to be perceived no sort of law except, at the most, that it is hooked to the heels of certain individuals, the so-called mediums. An authority which asserts this demands more than a scientific authority has ever demanded; it demands that natural Science shall abandon the presupposition of a universal causality, the presupposition upon which all the methods of her investigation rest, and without which an establishment of facts or even of laws of occurrence could never be spoken of.

You will agree with me that this would not be the place to enter upon any long discussion of the origin of the law of causation. You will also probably admit that the most favorable assumption which we could make for spiritualism would be that of its purely empirical origin. Empirical laws can at any time be refuted by other empirical laws. How now, with this premise, is the trustworthiness of a universal causality related to the trustworthiness of the spiritualistic phenomena? On the one side stands the authority of the whole history of science, the totality of all known natural laws, which have not only been discovered under the presupposition of a universal causality, but have also without exception confirmed the same; on the other side stands the authority of a few certainly most eminent naturalists, who, in all which they have discovered in the absence of mediumistic influences, have contributed their part to the confirmation of that most general result of natural investigation, but who now in this *one* point, under a constellation of circumstances which make exact observation difficult in the highest degree, announce the discovery that causality has a flaw and that we must consequently abandon our former view of nature.

I have spoken of the unfavorable constellations under which the spiritualistic phenomena were observed, and, since you might question the warrant of this expression, I must give it a somewhat better basis. I call the constellations unfavorable for observations or experiments, when the observer can not freely manage his senses and his instruments. You would yourself probably call it an unjust demand if a physicist were asked to observe the oscillations of a magnet through a key-hole or an astronomer to take a cellar for his observatory. Yet the observers of spiritualistic phenomena must content themselves with equally unfavorable conditions. The first condition of the success of the experiments is that all persons present shall lay their hands together upon a table and that no observer shall be outside the circle. Thereby a great part of the field of operation is withdrawn from the

observer's view. Mr. Slade, indeed, as the advices state, sometimes seats himself so that his legs are to be seen; but when this shall happen lies at the pleasure of Mr. Slade, not of the observer. So, in general, it is the medium who determines *when* a phenomenon shall appear and *whether* it shall appear. The observers propose experiments, the medium performs them. When a new proposal comes, the spirits answer, "We will try it," and sometimes the attempt succeeds and sometimes not. Occasionally, however, the phenomena desired by the observers are crossed by others entirely unexpected. By this alone the attention is thrown hither and thither in a way most disturbing for exact observations. This, too, occurs equally by reason of purely subjective visions, which the medium appears to have; now there are lights on the ceiling, to which he directs the attention of those present and of which they see nothing; now he falls into sudden convulsions, which must necessarily distract the attention. After all this, I find the expression, also used by yourself, that experiments are made *with* or *upon* Mr. Slade not correct. Rather, Mr. Slade made the experiments; and, if they were made upon any person, then they were made upon those who were present at his manifestations.

If now, respected sir, after a consideration of all the circumstances which are to be gathered from the reports of the *séances* with Mr. Slade, I place myself in that position of an unconcerned distant spectator, which until recently you were so fortunate as to occupy, it would not be to me a matter of question that I should not have written the article which you inserted in the last number of your valuable journal. But, as you had the goodness to remark, I do not find myself in quite that position, and must therefore finally advise you concerning what I saw myself. The state of the case is as follows.

There were present at the *séance*, as you have stated, besides myself, two of my colleagues, Herren Ludwig and Thiersch. We sat with Mr. Slade around a square card-table, one person on each side, our hands laid over each other upon the table. Several writings were produced, in the manner often described, upon a slate, which Mr. Slade held wholly or partially under the table; once a longer writing was obtained between two folded tablets joined by hinges. This double tablet was gradually drawn forward under the edge of the table by Slade *during* the experiment, so that for a short time it was entirely visible; Mr. Slade's hand, however, upon which the tablet rested, was not visible in this. (This, according to my recollection, is the experiment not quite correctly described in one of your notes.) Most of the writings were in English, one in German, but in an incorrect German, such as would be expected from an American or Englishman, who murders the language. Once the experiment with the pocket-knife was performed, quite in the manner you described. Throughout almost the entire *séance*, the door of the room was in violent commotion, such as gusts of wind might create; this explanation,

however, was excluded, since on that afternoon the air was perfectly still. Several times during the *séance* Mr. Slade fell into convulsions and asked me, who sat beside him, whether I felt anything, which, however, was not the case. The other persons present occasionally felt thrusts against their legs, and the tablet, which they held in their hands under the table, was violently pushed away; with myself this did not take place. At the end of the sitting we arose, Mr. Slade laid his hands upon ours and first lifted the table several inches from the floor, then letting it suddenly fall again; it was clearly perceptible that the table was raised by a central force from beneath. With our wish to perform some of the experiments in the presence of an observer standing outside the circle Mr. Slade could not comply. He said that under that condition the spirits did not obey him; he was, moreover, a perfectly passive observer, and must accommodate himself to the conditions which he had accidentally discovered to be favorable for his experiments. Incidentally he gave us intelligence concerning our own mediumistic endowments; me he declared to be a medium "of a strong power." How he came to this knowledge he did not communicate. To myself, as I will not neglect to mention, never in my life has anything appeared or happened which might warrant such a diagnosis.

If you ask me now whether I am in a condition to express a conjecture as to how these experiments were performed, I answer, No. At the same time, however, I must state that phenomena of this sort lie entirely outside the domain of the special training which I have acquired during my scientific career. It is known to every naturalist that one is able to judge an experiment correctly only when one has one's self experimented in a similar direction, and thus has an insight into the conditions of the origin of the phenomena. If I were really a medium "of a strong power," as Mr. Slade asserts, I should perhaps be in a better condition to answer your question; but, since this is not the case, you will certainly find it justifiable, if I do not go into hypotheses as to how the phenomena produced by Mr. Slade were brought about. What was surprising to me in the matter, however, and what will also surprise you, is that Mr. Slade also refused to give any information of this kind. He is a medium, he is an experimenter, and he must therefore know under what conditions the phenomena have their origin. He asserts that he knows nothing of them, but that his relation is a perfectly passive one. The latter, however, is plainly untrue, since the phenomena generally appear only in the *séances* held by him, and also, as a rule, in the order in which he wishes to produce them.

But, although we can not determine *how* Mr. Slade performs his experiments, I agree with you that we still may not in this case pass the field by as one foreign to us. For, as you very justly remark, natural science and philosophy are so actively interested in the ques-

tion concerning the reality or non-reality of the spiritualistic phenomena that we must take some sort of attitude toward it. I confess that, after all I have observed, this question would be for me an extremely painful one if, with you and the eminent men whose authority you follow, I had to regard as excluded every possible explanation of the phenomena in a natural way—in a way which leaves the universal law of causation untouched.

As to the experiments which I saw myself, I believe that they will not fail to produce upon every unprejudiced reader, who has ever seen skillful prestidigitateurs, the impression of well-managed feats of jugglery. You certainly, respected sir, as I think I may conclude from your article, appear scarcely to have accumulated experiences in this direction. This is perfectly intelligible in the case of one whose time has been occupied in earnest studies. But, before you pronounced judgment upon this question with so great precision, it would perhaps have been not altogether out of order, if I may venture to say so, to see and study the performances of a skillful magician. If, indeed, the independent experimental cultivation of this field is closed to us by the direction of our studies, we should still not neglect, before pronouncing a judgment, to become acquainted with phenomena which the most zealous disciples of spiritualism admit to have a close external relation to the spiritualistic manifestations. I can not find that any one of the experiments which I saw with Mr. Slade was above the powers of a good juggler. If the latter has, by means of a place chosen by himself, more extensive apparatus and assistants, more favorable conditions, so, on the other hand, it is not to be denied that Mr. Slade, by reason of the restriction to a smaller number of experiments, the fixing of the participants to a single table, and especially the fact that he does not need to keep to any programme, and that an experiment can occasionally miscarry without damaging his reputation, has advantages on his side. If the "professor of magic" now and then makes use of glitter and parade, in order to distract attention, Mr. Slade attains the same end, in perhaps a still more effectual manner, by means of the subjective fits to which he is exposed.

In my absence certainly much more astonishing performances took place than those which I saw myself. For my judgment of these performances, though other observers were convinced of their trustworthiness, is decisive. One who enters upon observations with this presupposition, will naturally regard as superfluous the precautions which another deems indispensable; he can leave unmentioned some incidental circumstances of the experiment, the knowledge of which would essentially change the estimate of it. This does not involve the slightest reproach against the observer; he acts in his good faith in the trustworthiness of his objects, in a faith which does honor to his feelings, to the same extent that it robs his observations of convincing power. Therefore, respected sir, there remains for me no

other choice in regard to these observations: I prefer the authority of Science to the authority of a few of her representatives, however honorable, who have, in this instance, made observations in a province which lies far from the sphere of their own special studies.

II.

Here I might conclude, passing silently over the hopes which you attach to the reality of the spiritualistic phenomena. But your inferences, philosophical, ethical, and religious, in relation to the subject, appear to me, as I have already observed, so important that they can not be without influence upon our attitude toward the entire question. Permit me, therefore, to betake myself for the moment to your own standpoint. I will assume, as you do, that the reality of the phenomena is no longer to be doubted. What follows from this for our general view of the world, for our judgment of the past and of the future? What effect does it have upon our moral and religious sentiment?

For the purpose of answering these questions, you discuss, in the first place, the hypotheses which we can form concerning the nature of the spiritualistic phenomena. There are three such hypotheses. We can possibly see in the phenomena—1. Expressions of natural forces; 2. Operations of intelligent beings, who belong to a space of *four* dimensions, and who, therefore, possess the power alternately to enter, in their movements, our space of three dimensions, and to vanish from the same into the to us inaccessible fourth dimension; 3. Manifestations of so-called spirits or ghosts. I prefer the latter term, because, according to philosophical usage, we understand by a spirit (*Geist*) an immaterial being, while "the spirits" occasionally undergo materialization, a property which is designated, unambiguously only, by the German word "*Gespenst*" (ghost, apparition). Like all who have engaged themselves with the subject, you reject the first hypothesis, since the phenomena point to arbitrary actions of intelligent beings; only the last two hypotheses, therefore, remain for us to consider.

Here, respected sir, you believe yourself compelled to decide *against* the hypothesis of intelligent beings of *four dimensions* and *for* the hypothesis of ghosts. I will not follow you in your argument, based upon the Kantian theory of knowledge; I would, however, beg to call your attention to the fact that there is no essential difference between the two hypotheses. By a ghost we understand an intelligent being that can suddenly appear in the world of our senses and as suddenly disappear from it again, leaving no traces behind, but we understand precisely the same by an intelligent being of four dimensions. Modern mathematics, as you very well know, has advanced in its speculations astonishingly far, and it has thereby gained the power to define with exactness numerous conceptions, for the designation of which we had

previously to employ common terms of speech. As the modern geometrician speaks of a "plane and in itself congruent manifold of three dimensions," without understanding by it anything else than the space well known to all of us, so he designates with the term "intelligent beings of four dimensions" simply what we ordinary men are accustomed to call ghosts. I believe now with you that the hypothesis which alone is left for us is at the same time the sole hypothesis which would be able to explain the phenomena—their reality being presupposed—and we can therefore confidently make it the basis of our further conclusions. For my own part, I should prefer the term "intelligent beings of four dimensions," because it is more scientific; but for the sake of brevity I will employ the current name of ghosts.

You now put the question—a question worth taking to heart—"Who are these ghosts?" Your deductions lead you to the conclusion that we have to see in them the souls of men who have died, which possess the power to assume again, partially or fully, their former bodily form. Although in Mr. Slade's sittings only detached members—hands and feet—became visible, partly immediately and partly in impressions, it still appears from American advices that materializations of entire bodies are not wanting. I can only assent to this conclusion. I am also essentially determined here by the impression, to which you refer—of a man's foot deformed by a tight shoe—upon a blackened tablet. The assumption that the beings of some other world unknown to us would naturally resemble us not only in their bodily constitution, but also in their dress, has to me only a very slight probability. I confess, indeed, that the thought that hard-hearted shoemakers might even in the next world continue their attempts to improve the anatomical structure of our feet gives me great uneasiness, while I could more easily reconcile myself to the idea that some abiding effects of sufferings here might accompany us into the future. Under this assumption, I count it not altogether impossible that a specialist might be able to conclude from the peculiar character of the deformity as to the period in which the possessor of the foot lived, and perhaps even as to the nation to which he belonged. I regret that this investigation does not appear to have been thought of.

We will assume, therefore, that the ghosts belonged to our deceased fellow men, who advise us in this way of their survival and their condition after death. What significance have the phenomena, then? You, respected sir, believe that you must view this significance as lying above all else in the fact that nothing could more powerfully strengthen our faith in a supreme moral government of the world, nothing more surely counteract the materialism and indifferentism of the time, than the certainty of immortality. To-day, when faith has become tottering, when, at the same time, there are no youthful races (like the Celts, the Teutons, the Slavs) able, as at the time of the decay of ancient civilization, "to take up the broken thread of civiliza-

tion and, upon the ideal loom which Christianity offered, to spin further"—to-day it may please Divine Providence to interfere with the course of nature in *this* way, in order to call back into the thoughts of men their moral nature and end. You acknowledge, indeed, that the written communications of the spirits have a very insignificant content, and that their other performances also seem to be substantially to no purpose; but you console yourself with the thought that the principle of development will also find its application in the other life, so that the souls of the dead only gradually attain the highest perfection of knowledge and will.

Here, unfortunately, I must oppose your conclusions in the most decided manner. I hold these conclusions to be as false as they are dangerous, and of this I will endeavor to convince you and your readers.

In the first place, I beg to call your attention to an unwarranted assumption which is intermingled with your conclusions. You conjecture that Providence, in consideration of the lamentable circumstances and conditions of the present, has felt itself bound to interfere in this peculiar manner. Your conjecture is based upon the assumption that similar phenomena have never been observed in former times. This assumption, however, is false. On the contrary, there has never been a time, so far as I know, when phenomena resembling the spiritualistic phenomena more or less, and in some respects most strikingly, were lacking. To say nothing of the everywhere common appearances of ghosts, I refer you to the facts which occur among numerous peoples and to which the anthropologists give the name of "Shamanism."* The so-called Shamans are manifestly persons with mediumistic properties. They even perform, by means of spirits, who obey their summons, many things which are often astounding, and not seldom resemble, down to the most particular features, the spiritualistic phenomena. I would further call your attention to the fact that, from the fourteenth century on until into the seventeenth, the spiritualistic manifestations, then designated by the terms witchcraft and magic, clearly reached an extent, compared with which their present circulation can be called a declining one. The witches appear, indeed, to have united to a certain extent the properties of the mediums and of the spirits. This, however, in view of the great strength in which the wonderful force was at that time apparently distributed, is quite intelligible. On the other hand, there are often very striking relations; for example, the canceling of the law of gravitation, observed also in recent times, was such an ordinary occurrence that, as is well known, the famous witches' ordeal was based upon it. We even pos-

* The term has primary reference to the superstitions of certain of the Siberian races, but phenomena similar to those observed among these people are met with in many parts of the world, in the Pacific islands, for instance, and among the Indian "medicine-men." —TRANSLATOR.

sess numerous certificates of judges, whose credibility can certainly not be unconditionally denied, according to which a witch sometimes weighed *only half an ounce*, sometimes even nothing at all. You answer that all this belongs to the realm of superstition, and that the pretended facts were never investigated by trustworthy observers. But upon what is this assumption of superstition founded? Simply upon the fact that we have hitherto held the things in question to be impossible. Now you maintain not only the possibility but also the actuality of phenomena equally astonishing, and, moreover, very similar. By all rules of scientific investigation, we are logically bound to assume that those earlier phenomena also may, indeed, in many instances have rested upon deception, but that they were scarcely altogether without foundation. There was of course a lack of exact observers in those days. But do you believe that the Galileian laws of falling bodies were not in force before Galileo demonstrated them by his experiments? There opens up to us from your standpoint an essentially new view of history. Phenomena hitherto regarded as lamentable expressions of a corrupting superstition are transformed into evidences of an especially gracious dissemination of supersensible mysteries.

But I proceed to your real conclusions themselves. The spiritualistic phenomena, silly as they may be in detail, pass with you, by reason of the certainty which they give of another world, as a new source of moral and religious conviction. Our opinion hitherto has been that Providence veiled the future from men with a wise purpose; that its will was to leave the religious nature to form for itself a moral ideal, which should remain untouched by the imperfections of the world of sense. This condition of things is by your view essentially changed. Our future destiny is no longer a subject of moral demands and religious convictions, but, to a certain extent at least, belongs to our knowledge and perception. You do indeed lay stress upon the fact that precisely that phase of the other world which we perceive may be the less perfect phase. That might pass, if at least the beginning of a process of perfection were apparent to us. But I see only the shocking contrary of this. What conception must we form of the condition of our deceased fellow men, if your view is correct? I find myself forced to the following conclusions, against which, so far as I can see, you can urge no material objections:

1. *Physically* the souls of our dead fall into the bondage of certain living men, the so-called mediums. These mediums are, at present at any rate, not very widely spread, and appear to belong almost exclusively to the American nationality. At the command of the mediums, the souls execute mechanical performances, which bear throughout the character of purposelessness: they knock, lift tables and chairs, play harmoniums, etc.

2. *Intellectually* the souls fall into a condition which, so far as

we can conclude from the character of their writings upon slates, can only be described as lamentable. These writings belong throughout to the domain of higher or lower stupidity, chiefly lower—i. e., they are absolutely without sense.

3. The *moral* condition of the souls seems to be relatively the most favorable. According to all the evidence, the character of harmlessness can not be denied them. It shows itself particularly in the fact that they hold it to be necessary to make excuses for proceedings of a somewhat brutal nature, in case of becoming guilty of such—as, for instance, the destruction of a bed-screen, with a politeness which, in a ghost, is certainly deserving of acknowledgment. This harmlessness, therefore, gives us a right to expect something good of their other moral qualities, concerning which nothing particular is known.

Pardon me if I seem to joke. You would misunderstand me if you should believe that I had adduced these consequences of your premises with any other intention than that of indicating as forcibly as possible the earnest scientific, moral, and religious anxiety which the views that you represent in your latest essay must necessarily awaken.

I will not speak of how, even in the most favorable case of your example finding no further following, the science which concerns us both most nearly, philosophy, can not be without danger of having its reputation severely damaged, when one of its distinguished representatives, who has treated almost all of its departments and has especially occupied himself earnestly with logical studies, now suddenly throws overboard all principles of scientific investigation, in order to find in the revelations of rapping spirits the means of supplementing our insight into the order of the world. The specialist in scientific investigation has the prerogative of a certain one-sidedness; we justify many a freak in his narrower field which can not abide the test of criticism. But what is to become of philosophy, if it abandons the general principles of knowledge, whose authority it is its office to establish for the special sciences? Yet even this particular interest is of subordinate importance, compared with the serious consequences which your procedure must have, if, which God forbid, it should find more followers in the scientific world. Whence is the scientific investigator to get courage and perseverance for his work, if the laws of nature, according to the prospect which you open, are approaching a point where they shall be done away with? And who will still be inclined to occupy himself with scientific problems, when he is allured by the hope of obtaining an answer to the deepest and highest questions by means of spiritualistic appearances? It is true that the disclosures already won in this way are good for nothing. But how were it possible for individuals and societies to spend their time in these idle occupations, if they did not hope for better results? A mournful intellectual desolation would be the necessary consequence, if views such as you pro-

claim to-day should ever become the common property of the scientific world.

This might pass, however, if that moral and religious awakening which you hope from the spiritualistic manifestations were really to be expected from them, according to the teachings of history and the laws of human nature. I almost hesitate to say to you that the moral deepening of religion has continually kept pace with the doing away of rude representations of the divine in forms of sense, and that, alongside weak-minded unbelief, the worst enemy of morality has always been superstition.

These are things long well known to you. You indeed declare the phenomena to which you refer to be realities, and therefore different from the objects of superstition. But every superstition has done that. Not upon *whether* one believes in certain phenomena or not, but only upon the *objects* in which one believes, can the corrupting effects of superstition depend. The moral barbarism produced in its time by the belief in witchcraft would have been precisely the same, if there had been real witches. We can therefore leave the question entirely alone, whether or not you have ground to believe in the spiritualistic phenomena. We can content ourselves with considering the question, whether the objects of your belief show the characteristic signs which we find in those objects of belief which, according to the testimony of history and of social psychology, we must call prejudicial to the moral development of man. This question, after the intimate relation which we have shown to exist between spiritualism and the most corrupt forms of so-called superstition, can only be answered in the affirmative. The reasons for this demoralizing influence, as you as a psychologist will easily perceive, are also perfectly apparent. The danger of estrangement from earnest work, devoted to the service of science or of a practical calling, which I have already touched, is to be included here, if indeed in a subordinate place. Of far greater importance are the unworthy conceptions of the condition of the spirit after death, which these phenomena awaken, and which find their analogy only in the so-called animism of the most degraded races. But most pernicious of all appears to me the caricature which the spiritualistic system, in the form in which you represent it, makes of the rule of a higher order of the world, by making men of, at the very least, most ordinary intellectual and spiritual endowments the bearers of supernatural powers, thereby sealing them as the chosen instruments of Providence. In all these features, and above all in the materialization of the ghosts, there is betrayed a grossly materialistic tendency, of which, as I am glad to believe, most of the German spiritualists are not conscious. They are only the pitiable victims of exotic Shamans, who have transplanted to Europe the animistic conceptions which have not entirely disappeared in their home. From a philosopher this materialistic character of spiritualism ought not to have remained

concealed. Astonishingly, however, you see in it nothing less than a contrivance of Providence for counteracting the materialism of the present. This is to me the most incomprehensible part of your essay. I see in spiritualism, on the contrary, a sign of the materialism and the barbarism of our time. From early times, as you well know, materialism has had two forms; the one denies the spiritual, the other transforms it into matter. The latter form is the older. From the animism of the popular mythologies, it passes into philosophy, in order to be by the latter gradually overcome. As civilized barbarism can experience relapses into all forms of primitive conditions, so it is not spared from this also.

That, in your person, philosophy too has shared in this relapse, I count most melancholy. Above all else, however, I deplore the possible influence of your example upon our academical youth, among whose instructors you belong. What would become of science, if pursuits which your views only too easily encourage should become prevalent among our students; if earnest work and the emulation of scientific studies should become supplanted among them by an aimless chase after wonders and by rapping-spirit clubs? I have such firm confidence in the sound sense of our youth, that I am sure these fears will not be realized. Nevertheless, I held it to be my duty no longer to remain a silent spectator, but to answer your challenge. I sincerely hope, at the same time, that my answer may succeed in prompting you to another careful consideration of the subject. Then perhaps I may not entirely relinquish the hope that we may one day find ourselves with a common feeling concerning this question.

With this wish, I remain, with high esteem, yours,

W. Wundt.

GEOGRAPHICAL EVOLUTION.

By Professor ARCHIBALD GEIKIE, F. R. S.

II.

THE ARCHITECTURE OF THE LAND.—Let us now proceed to consider how these materials, sedimentary and crystalline, have been put together, so as to constitute the solid land of the globe.

It requires but a cursory examination to observe that the sedimentary masses have not been huddled together at random; that, on the contrary, they have been laid down in sheets one over the other. An arrangement of this kind at once betokens a chronological sequence. The rocks can not all have been formed simultaneously. Those at the bottom must have been laid down before those at the top. A truism of this kind seems hardly to require formal statement. Yet it lies at

the very foundation of any attempt to trace the geological history of a country. Did the rocks everywhere lie undisturbed one above another as they were originally laid down, their clear order of succession would carry with it its own evident interpretation. But such have been the changes that have arisen, partly from the operation of forces from below, partly from that of forces acting on the surface, that the true order of a series of rocks is not always so easily determined. By starting, however, from where the succession is normal and unbroken, the geologist can advance with confidence into regions where it has been completely interrupted—where the rocks have been shattered, crumpled, and even inverted.

The clew which guides us through these labyrinths is a very simple one. It is afforded by the remains of once living plants and animals which have been preserved in the rocky framework of the land. Each well-marked series of sedimentary accumulations contains its own characteristic plants, corals, crustaceans, shells, fishes, or other organic remains. By these it can be identified and traced from country to country across a whole continent. When, therefore, the true order of superposition of the rocks has been ascertained by observing how they lie upon each other, the succession of their fossils is at the same time fixed. In this way the sedimentary part of the earth's crust has been classified into different formations, each characterized by its distinct assemblage of organic remains. In the most recent formations, most of these remains are identical with still living species of plants and animals; but as we descend in the series and come into progressively older deposits, the proportion of existing species diminishes until at last all the species of fossils are found to be extinct. Still older and lower rocks reveal types and assemblages of organisms which depart further and further from the existing order.

By noting the fossil contents of a formation, therefore, even in a district where the rocks have been so disturbed that their sequence is otherwise untraceable, the geologist can confidently assign their relative position to each of the fractured masses. He knows, for instance (using for our present purpose the letters of the alphabet to denote the sequence of the formations), that a mass of limestone containing fossils typical of the formation B must be younger than another mass of rock containing the fossils of A. A series of strata full of the fossils of H resting immediately on others charged with those of C, must evidently be separated from these by a great gap, elsewhere filled in by the intervening formations D, E, F, G. Nay, should the rocks in the upper part of a mountain be replete with the fossils proper to D, while those in the lower slopes showed only the fossils of E, F, and G, it could be demonstrated that the materials of the mountain had actually been turned upside down, for, as proved by its organic remains, the oldest and therefore lowest formation had come to lie at the top, and the youngest, and therefore highest, at the bottom.

Of absolute chronology in such questions science can as yet give no measure. How many millions of years each formation may have required for its production, and how far back in time may be the era of any given group of fossils, are problems to which no answer, other than a mere guess, can be returned. But this is a matter of far less moment than the relative chronology, which can usually be accurately fixed for each country, and on which all attempts to trace back the history of the land must be based.

While, then, it is true that most of the materials of the solid land have been laid down at successive periods under the sea, and that the relative dates of their deposition can be determined, it is no less certain that the formation of these materials has not proceeded uninterruptedly, and that they have not finally been raised into land by a single movement. The mere fact that they are of marine origin shows, of course, that the land owes its origin to some kind of terrestrial disturbance. But, when the sedimentary formations are examined in detail, they present a most wonderful chronicle of long-continued, oft-repeated, and exceedingly complex movements of the crust of the globe. They show that the history of every country has been long and eventful; that, in short, hardly any portion of the land has reached its present condition, save after a protracted series of geological revolutions.

One of the most obvious and not the least striking features in the architecture of the land is the frequency with which the rocks, though originally horizontal, or approximately so, have been tilted up at various angles, or even placed on end. At first it might be supposed that these disturbed positions have been assumed at random, according to the capricious operations of subterranean forces. They seem to follow no order, and to defy any attempt to reduce them to system. Yet a closer scrutiny serves to establish a real connection among them. They are found, for the most part, to belong to great though fractured curves, into which the crust of the earth has been folded. In low countries far removed from any great mountain-range, the rocks often present scarcely a trace of disturbance, or, if they have been affected, it is chiefly by having been thrown into gentle undulations. As we approach the higher grounds, however, they manifest increasing signs of commotion. Their undulations become more frequent and steeper, until, entering within the mountain-region, we find the rocks curved, crumpled, fractured, inverted, tossed over each other into yawning gulf and towering crest, like billows arrested at the height of a furious storm.

Yet even in the midst of such apparent chaos it is not impossible to trace the fundamental law and order by which it is underlaid. The prime fact to be noted is the universal plication and crumpling of rocks which were at first nearly horizontal. From the gentle undulations of the strata beneath the plains to their violent contortion and inversion among the mountains, there is that insensible gradation which connects

the whole of these disturbances as parts of one common process. They can not be accounted for by any mere local movements, though such movements no doubt took place abundantly. The existence of a mountain-chain is not to be explained by a special upheaval or series of upheavals caused by an expansive force acting from below. Manifestly the elevation is only one phase of a vast terrestrial movement which has extended over whole continents, and has affected plains as well as high grounds.

The only cause which, so far as our present knowledge goes, could have produced such wide-spread changes is a general contraction of the earth's mass. There can be no doubt that at one time our planet existed in a gaseous, then in a liquid condition. Since these early periods it has continued to lose heat, and consequently to contract and to grow more and more solid, until, as the physicists insist, it has now become practically as rigid as a globe of glass or of steel. But in the course of the contraction, after the solid external crust was formed, the inner hot nucleus has lost heat more rapidly than the crust, and has tended to shrink inward from it. As a consequence of this internal movement, the outer solid shell has been obliged to sink down upon the retreating nucleus. In so doing, it has of course had to accommodate itself to a diminished area, and this it could only accomplish by undergoing plication and crumpling. Though the analogy is not a very exact one, we may liken our globe to a shriveled apple. The skin of the apple does not contract equally. As the internal moisture passes off, and the bulk of the fruit is reduced, the once smooth exterior becomes here and there corrugated and dimpled.

Without entering into this difficult problem in physical geology, it may suffice if we carry with us the idea that our globe must once have had a greater diameter than it now possesses, and that the crumpling of its outer layers, whether due to mere contraction or, as has been suggested, to the escape also of subterranean vapors, affords evidence of this diminution. A little reflection suffices to show us that, even without any knowledge of the actual history of the contraction, we might anticipate that the effects would neither be continuous nor everywhere uniform. The solid crust would not, we may be sure, subside as fast as the mass inside. It would, for a time at least, cohere and support itself, until at last, gravitation proving too much for its strength, it would sink down. And the areas and amount of descent would be greatly regulated by the varying thickness and structure of the crust. Subsidence would not take place everywhere; for, as a consequence of the narrower space into which the crust sank, some regions would necessarily be pushed up. These conditions appear to have been fulfilled in the past history of the earth. There is evidence that the terrestrial disturbance has been renewed again and again, after long pauses, and that, while the ocean-basins have on the whole been the great areas of depression, the continents have been the lines

of uprise or relief, where the rocks were crumpled and pushed out of the way. Paradoxical, therefore, as the statement may appear, it is nevertheless strictly true that the solid land, considered with reference to the earth's surface as a whole, is the consequence of subsidence rather than of upheaval.

Grasping, then, this conception of the real character of the movements to which the earth owes its present surface configuration, we are furnished with fresh light for exploring the ancient history and growth of the solid land. The great continental ridges seem to lie nearly on the site of the earliest lines of relief from the strain of contraction. They were forced up between the subsiding oceanic basins at a very early period of geological history. In each succeeding epoch of movement they were naturally used over again, and received an additional push upward. Hence we see the meaning of the evidence supplied by the sedimentary rocks as to shallow seas and proximity of land. These rocks could not have been otherwise produced. They were derived from the waste of the land, and were deposited near the land. For it must be borne in mind that every mass of land, as soon as it appeared above water, was at once attacked by the ceaseless erosion of moving water and atmospheric influences, and immediately began to furnish materials for the construction of future lands, to be afterward raised out of the sea.

Each great period of contraction elevated anew the much-worn land, and, at the same time, brought the consolidated marine sediments above water as parts of a new terrestrial surface. Again a long interval would ensue, marked perhaps by a slow subsidence both of the land and sea-bottom. Meanwhile the surface of the land was channeled and lowered, and its detritus was spread over the sea-floor, until another era of disturbance raised it once more with a portion of the surrounding ocean-bed. These successive upward and downward movements explain why the sedimentary formations do not occur as a continuous series, but often lie each upon the upturned and worn edge of its predecessors.

Returning now to the chronological sequence indicated by the organic remains preserved among the sedimentary rocks, we see how it may be possible to determine the relative order of the successive upheavals of a continent. If, for example, a group of rocks, which, as before, may be called A, were found to have been upturned and covered over by undisturbed beds C, the disturbance could be affirmed to have occurred at some part of the epoch represented elsewhere by the missing series B. If, again, the group C were observed to have been subsequently tilted, and to pass under gently-inclined or horizontal strata E, a second period of disturbance would be proved to have occurred between the time of C and E.

I have referred to the unceasing destruction of its surface which the land undergoes from the time when it emerges out of the sea. As

a rule, our conceptions of the rate of this degradation are exceedingly vague. Yet they may easily be made more definite by a consideration of present changes on the surface of the land. Every river carries yearly to the sea an immense amount of sand and mud. But this amount is capable of measurement. It represents, of course, the extent to which the general level of the surface of the river's drainage-basin is annually lowered. According to such measurements and computations as have been already made, it appears that somewhere about $\frac{1}{6000}$ of a foot is every year removed from the surface of its drainage-basin by a large river. This seems a small fraction, yet by the power of mere addition it soon mounts up to a large total. Taking the mean level of Europe to be 600 feet, its surface, if everywhere worn away at what seems to be the present mean normal rate, would be entirely reduced to the sea-level in little more than three and a half millions of years.

But of course the waste is not uniform over the whole surface. It is greatest on the slopes and valleys, least on the more level grounds. A few years ago, in making some of the estimates of the ratios between the rates of waste on these areas, I assumed that the tracts of more rapid erosion occupy only one ninth of the whole surface affected, and that in these the rate of destruction is nine times greater than on the more level spaces. Taking these proportions, and granting that $\frac{1}{6000}$ of a foot is the actual ascertained amount of loss from the whole surface, we ascertain by a simple arithmetical process that $\frac{1}{12}$ of an inch is carried away from the plains and table-lands in seventy-five years, while the same amount is worn out of the valleys in eight and a half years. One foot must be removed from the former in 10,800 years, and from the latter in 1,200 years. Hence we learn that at the present rate of erosion a valley 1,000 feet deep may be excavated in 1,200,000 years—by no means a very long period in the conceptions of most geologists.

I do not offer these figures as more than tentative results. They are based, however, not on mere guesses, but on data which, though they may be corrected by subsequent inquiry, are the best at present available, and are probably not far from the truth. They are of value in enabling us more vividly to realize how the prodigious waste of the land, proved by the existence of such enormous masses of sedimentary rock, went quietly on age after age, until results were achieved which seem at first scarcely possible to so slow and gentle an agency.

It is during this quiet process of decay and removal that all the distinctive minor features of the land are wrought out. When first elevated from the sea, the land doubtless presents on the whole a featureless surface. It may be likened to a block of marble raised out of the quarry—rough and rude in outline, massive in solidity and strength, but giving no indication of the grace into which it will grow under the hand of the sculptor. What art effects upon the marble block, Nature accomplishes upon the surface of the land. Her tools are many and

varied—air, frost, rain, springs, torrents, rivers, avalanches, glaciers, and the sea—each producing its own characteristic traces in the sculpture. With these implements, out of the huge bulk of the land she cuts the valleys and ravines, scoops the lake-basins, hews with bold, free hand the colossal outline of the mountains, carves out peak and crag, crest and cliff, chisels the courses of the torrents, splinters the sides of the precipices, and leaves her impress upon every lineament of the land. Patiently and unceasingly has this great earth-sculptor sat at her task since the land first rose above the sea, washing down into the ocean the *débris* of her labor, to form the materials for the framework of future countries; and there will she remain at work, so long as mountains stand, and rain falls, and rivers flow.

The Growth of the European Continent.—Passing now from the general principles with which we have hitherto been dealing, we may seek an illustration of their application to the actual history of a large mass of land. For this purpose, let me ask your attention to some of the more salient features in the gradual growth of Europe. This continent has not the simplicity of structure elsewhere recognizable; but, without entering into detail or following a continuous sequence of events, our present purpose will be served by a few broad outlines of the condition of the European area at successive geological periods.

It is the fate of continents, no less than of the human communities that inhabit them, to have their first origin shrouded in obscurity. When the curtain of darkness begins to rise from our primeval Europe, it reveals to us a scene marvelously unlike that of the existing continent. The land then lay chiefly to the north and northwest, probably extending as far as the edge of the great submarine plateau by which the European ridge is prolonged under the Atlantic for 230 miles to the west of Ireland. Worn fragments of that land exist in Finland, Scandinavia, and the northwest of Scotland, and there are traces of what seem to have been some detached islands in Central Europe, notably in Bohemia and Bavaria. Its original height and extent can of course never be known; but some idea of them may be formed by considering the bulk of solid rock which was formed out of the waste of that land. I find that if we take merely one portion of the detritus washed from its surface and laid down in the sea, viz., that which is comprised in what is termed the Silurian system, and if we assume that it spreads over 60,000 square miles of Britain with an average thickness of 16,000 feet, or three miles, which is probably under the truth, then we obtain the enormous mass of 180,000 cubic miles. The magnitude of this pile of material may be better realized if we reflect that it would form a mountain-ridge three times as long as the Alps, or from the North Cape to Marseilles (1,800 miles), with a breadth of more than thirty-three miles, and an average height of 16,000 feet, that is, higher than the summit of Mont Blanc. All this vast pile of sedimentary rock was worn from the slopes and shores of the primeval northern land. Yet it represents but

a small fraction of the material so removed, for the sea of that ancient time spread over nearly the whole of Europe eastward into Asia, and everywhere received a tribute of sand and mud from the adjoining shores.

There is perhaps no mass of rock so striking in its general aspect as that of which this northern embryo of Europe consisted. It lacks the variety of composition, structure, color, and form, which distinguishes rocks of more modern growth. But in dignity of massive strength it stands altogether unrivaled. From the headlands of the Hebrides to the far fiords of Arctic Norway it rises up grim and defiant of the elements. Its veins of quartz, feldspar, and hornblende project from every boss and crag like the twisted and knotted sinews of a magnificent torso. Well does the old gneiss of the north deserve to have been made the foundation-stone of a continent.

Whether vegetation clothed this earliest prototype of Europe, and, if so, what were its characters, are questions to which at present no answer is possible. We know, however, that the shallow sea which spread from the Atlantic southward and eastward over most of Europe was tenanted by an abundant and characteristic series of invertebrate animals—trilobites, graptolites, cystideans, brachiopods, and cephalopods, strangely unlike on the whole to anything living in our waters now, but which then migrated freely along the shores of the Arctic land between what are now America and Europe.

The floor of this shallow sea continued to sink until over Britain at least it had gone down several miles. Yet the water remained shallow because the amount of sediment constantly poured into it from the northwest filled it up about as fast as the bottom subsided. This slow subterranean movement was varied by uprisings here and there, notably by the outburst at successive periods of a great group of active submarine volcanoes over Wales, the Lake District, and the south of Ireland. But at the close of the Silurian period a vast series of disturbances took place, as the consequence of which the first rough outlines of the European Continent were blocked out. The floor of the sea was raised into long ridges of land, among which were some on the site of the Alps, the Spanish Peninsula, and the hills of the west and north of Britain. The thick mass of marine sediment was crumpled up, and here and there even converted into hard crystalline rock. Large inclosed basins, gradually cut off from the sea, like the modern Caspian and the Sea of Aral, extended from beyond the west of Ireland across to Scandinavia and even into the west of Russia. These lakes abounded in bone-covered fishes of strange and now long-extinct types, while the land around was clothed with a club-moss and reed-like vegetation—*Psilophyton*, *Sigillaria*, *Calamite*, etc.—the oldest terrestrial flora yet known in Europe. The sea, dotted with numerous islands, appears to have covered most of the heart of the continent.

A curious fact deserves to be noticed here. During the convulsions by which the sediments of the Silurian sea-floor were crumpled up, crystallized, and elevated into land, the area of Russia seems to have remained nearly unaffected. Not only so, but the same immunity from violent disturbance has prevailed over that vast territory during all subsequent geological periods. The Ural Mountains on the east have again and again served as lines of relief, and have been from time to time ridged up anew. The German domains on the west have likewise suffered extreme convulsion. But the wide intervening plateau of Russia has apparently always maintained its flatness either as sea-bottom or as terrestrial plains.

By the time of the coal-growths, the aspect of the European area had still further changed. It then consisted of a series of low ridges or islands in the midst of a shallow sea or of wide salt-water lagoons. A group of islands occupied the site of some of the existing high grounds of Britain. A long, irregular ridge ran across what is now France from Brittany to the Mediterranean. The Spanish Peninsula stood as a detached island. The future Alps rose as a long, low ridge, to the north of the eastern edge of which lay another insular space, where now we find the high grounds of Bavaria and Bohemia. The shallow waters which wound among these scattered patches of land were gradually silted up. Many of them became marshes, crowded with a most luxuriant cryptogamic vegetation, specially of lycopods and ferns, while the dry grounds waved green with coniferous trees. By a slow intermittent subsidence, islet after islet sank beneath the verdant swamps. Each fresh depression submerged the rank jungles and buried them under sand and mud, where they were eventually compressed into coal. To this united coöperation of dense vegetable growth, accumulation of sediment, and slow subterranean movement, Europe owes her coal-fields.

All this time the chief area of high ground in Europe appears still to have lain to the north and northwest. The old gnarled gneiss of that region, though constantly worn down and furnishing materials toward each new formation, yet rose up as land. It no doubt received successive elevations, during the periods of disturbance, which more or less compensated for the constant loss from its surface.

The next scene we may contemplate brings before us a series of salt lakes, covering the center of the continent from the north of Ireland to the heart of Poland. These basins were formed by the gradual cutting off of portions of the sea which had spread over the region. Their waters were red and bitter, and singularly unfavorable to life. On the low intervening ridges a coniferous and cycadaceous vegetation grew, sometimes in quantity sufficient to supply materials for the formation of coal-seams. The largest of these salt lakes stretched from the edge of the old plateau of Central France along the base of the Alpine ridge to the high grounds of Bohemia, and included the

basin of the Rhine from Basel down to the ridge beyond Mayence, which has been subsequently cut through by the river into the picturesque gorges between Bingen and the Siebengebirge. This lake was filled up with red sand and mud, limestone, and beds of rock-salt. Where the eastern Alps now rise, the inclosed water-basins were the scene of a long-continued growth of dolomite, out of which in later ages the famous dolomite mountains of the Tyrol were carved.

These salt lakes of the Triassic period seem to have been everywhere quietly effaced by a wide-spread depression, which allowed the water of the main ocean once more to overspread the greater part of Europe. This slow subsidence went on so long as to admit of the accumulation of masses of limestone, shale, and sandstone, several thousand feet in thickness, and probably to bring most of the insular tracts of Central Europe under water. To this period, termed by geologists the Jurassic, we can trace back the origin of a large part of the rock now forming the surface of the continent, from the low plains of Central England up to the crests of the northern Alps, while in the Mediterranean basin, rocks of the same age cover a large area of the plateau of Spain, and form the central mass of the chain of the Apennines. It is interesting to know that the northwest of Britain continued still to rise as land in spite of all the geographical changes which had taken place to the south and east. We can trace even yet the shores of the Jurassic sea along the skirts of the mountains of Skye and Ross-shire.

The next long era, termed the Cretaceous, was likewise more remarkable for slow accumulation of rock under the sea than for the formation of new land. During that time the Atlantic sent its waters across the whole of Europe and into Asia. But they were probably nowhere more than a few hundred feet deep over the site of our continent, even at their deepest part. Upon their bottom there gathered a vast mass of calcareous mud, composed in great part of foraminifera, corals, echinoderms, and mollusks. Our English chalk which ranges across the north of France, Belgium, Denmark, and the north of Germany, represents a portion of the deposits of that sea-floor. Some of the island spaces which had remained for a vast period above water, and had by their degradation supplied materials for the sediment of successive geological formations, now went down beneath the Cretaceous sea. The ancient high-grounds of Bohemia, the Alps, the Pyrenees, and the Spanish table-land, were either entirely submerged, or at least had their area very considerably reduced. The submergence likewise affected the northwest of Britain; the western Highlands of Scotland lay more than one thousand feet below their present level.

When we turn to the succeeding geological period, that of the Eocene, the proofs of wide-spread submergence are still more striking. A large part of the Old World seems to have sunk down; for we find that one wide stretch of sea extended across the whole of Central

Europe and Asia. It was at the close of this period of extreme depression that those subterranean movements began to which the present configuration of Europe is mainly due. The Pyrenees, Alps, Apennines, Carpathians, the Caucasus, and the heights of Asia Minor mark as it were the crests of the vast earth-waves into which the solid framework of Europe was then thrown. So enormous was the contortion that, as may be seen along the northern Alps, the rocks for thousands of feet were completely inverted, this inversion being accompanied by the most colossal folding and twisting. The massive sedimentary formations were crumpled up, and doubled over each other, as we might fold a pile of cloth. In the midst of these commotions the west of Europe remained undisturbed. It is strange to reflect that the soft clays and sands under London are as old as some of the hardened rocks which have been upheaved into such picturesque peaks along the northern flanks of the Alps.

After the completion of these vast terrestrial disturbances, the outlines of Europe began distinctly to shape themselves into their present form. The Alps rose as a great mountain-range, flanked on the north by a vast lake which covered all the present lowlands of Switzerland, and stretched northward across a part of the Jura Mountains, and eastward into Germany. The size of this fresh-water basin may be inferred from the fact that one portion only of the sand and gravel that accumulated in it even now measures six thousand feet in thickness. The surrounding land was densely clothed with a vegetation indicative of a much warmer climate than Europe now can boast. Palms of American types, as well as date-palms, huge Californian pines (Sequoia), laurels, cypresses, and evergreen oaks, with many other evergreen trees, gave a distinctive character to the vegetation. Among the trees too were planes, poplars, maples, willows, oaks, and other ancestors of our living woods and forests; numerous ferns grew in the underwood, while clematis and vine wound themselves among the branches. The waters were haunted by huge pachyderms, such as the dinotherium and hippopotamus; while the rhinoceros and mastodon roamed through the woodlands.

A marked feature of this period in Europe was the abundance and activity of the volcanoes. In Hungary, Rhineland, and Central France, numerous vents opened and poured out their streams of lava and showers of ashes. From the south of Antrim, also, another great line of active orifices ran up the west coast of Scotland and by the Faroe Islands to Iceland, whence it extended even far into Arctic Greenland.

The mild climate indicated by the vegetation in the deposits of the Swiss lake, prevailed even into polar latitudes, for the remains of numerous evergreen shrubs, oaks, maples, walnuts, hazels, and many other trees, have been found under the sheets of lava in the far north of Greenland. The sea still occupied much of the lowlands of Europe.

Thus it ran as a strait between the Bay of Biscay and the Mediterranean, cutting off the Pyrenees and Spain from the rest of the continent. It swept round the north of France, covering the rich fields of Touraine and the wide flats of the Netherlands. It rolled far up the plains of the Danube and stretched thence eastward across the south of Russia into Asia.

By this time not a few of the species of shells which still people the European seas had appeared. So long have they been natives of our area that they have witnessed the rise of a great part of the continent. Some of the most stupendous changes which they have seen have taken place in the basin of the Mediterranean, where, at a comparatively recent geological period, parts of the sea-floor have been upheaved to a height of three thousand feet. It was then that the breadth of the Italian Peninsula was increased by the belt of lower hills that flanks the range of the Apennines. Then, too, Vesuvius and Etna began their eruptions. Among these later geographical events also we must place the gradual isolation of the Sea of Aral, the Caspian, and the Black Sea from the rest of the ocean, which once spread from the Arctic regions down the west of Asia, along the base of the Ural Mountains into the southeast of Europe.

The last scene in this long history is one of the most unexpected of all. Europe, having nearly its present height and outlines, is swathed deep in snow and ice. Scandinavia and Finland are one vast sheet of ice, that creeps down from the watershed into the Atlantic on the one side, and into the basin of the Baltic on the other. All the high grounds of Britain are similarly buried. The bed of the North Sea as well as of the Baltic is in great measure choked with ice. The Alps, the Pyrenees, the Carpathians, and the Caucasus send down vast glaciers into the plains at their base. Northern plants find their way south even to the Pyrenees, while the reindeer, musk-ox, lemming, and their Arctic companions roam far and wide over France.

As a result of the prolonged passage of solid masses of ice over them, the rocks on the surface of the continent, when once more laid bare to the sun, present a worn, flowing outline. They have been hollowed into basins, ground smooth, and polished. Long mounds and wide sheets of clay, gravel, and sand have been left over the low grounds, and the hollows between them are filled with innumerable tarns and lakes. Crowds of bowlders have been perched on the sides of the hills and dropped over the plains. With the advent of a milder temperature the Arctic vegetation has gradually disappeared from the plains. Driven up step by step before the advancing flora from more genial climates, it retired into the mountains and there to this day continues to maintain itself. The present Alpine flora of the Pyrenees, the Alps, Britain, and Scandinavia, is thus a living record of the ice age. The reindeer and his friends have long since been forced to return to their northern homes.

After this long succession of physical revolutions, man appears as a denizen of the Europe thus prepared for him. The earliest records of his presence reveal him as a fisher and hunter, with rude flint-pointed spear and harpoon. And doubtless for many a dim century such was his condition. He made no more impress on external nature than one of the beasts which he chased. But in course of time, as civilization grew, he asserted his claim to be one of the geographical forces of the globe. Not content with gathering the fruits and capturing the animals which he found needful for his wants, he gradually entered on a contest with Nature to subdue the earth and to possess it. Nowhere has this warfare been fought out so vigorously as on the surface of Europe. On the one hand, wide dark regions of ancient forest have given place to smiling cornfields. Peat and moor have made way for pasture and tillage. On the other hand, by the clearance of woodlands the rainfall has been so diminished that drought and barrenness have spread where verdure and luxuriance once prevailed. Rivers have been straightened and made to keep their channels, the sea has been barred back from its former shores. For many generations the surface of the continent has been covered with roads, villages, and towns, bridges, aqueducts, and canals, to which this century has added a multitudinous network of railways, with their embankments and tunnels. In short, wherever man has lived, the ground beneath him bears witness to his presence. It is slowly covered with a stratum either wholly formed by him or due in great measure to his operations. The soil under old cities has been increased to a depth of many feet by the rubbish of his buildings; the level of the streets of modern Rome stands high above that of the pavement of the Cæsars, and that again above the roadways of the early republic. Over cultivated fields his potsherds are turned up in abundance by the plow. The loam has risen within the walls of his graveyards as generation after generation has moldered into dust.

It must be owned that man, in most of his struggles with the world around him, has fought blindly for his own ultimate interests. His contest, successful for the moment, has too often led to sure and sad disaster. Stripping forests from hill and mountain, he has gained his immediate object in the possession of their abundant stores of timber; but he has laid open the slopes to be parched by drought, or to be swept bare by rain. Countries once rich in beauty, and plenteous in all that was needful for his support, are now burned and barren, or almost denuded of their soil. Gradually he has been taught by his own bitter experience, that while his aim still is to subdue the earth, he can attain it, not by setting Nature and her laws at defiance, but by enlisting them in his service. He has learned at last to be the minister and interpreter of Nature, and he finds in her a ready and unrepining slave.

In fine, looking back across the long cycles of change through which

the land has been shaped into its present form, let us realize that these geographical revolutions are not events wholly of the dim past, but that they are still in progress. So slow and measured has been their march, that even from the earliest times of human history they seem hardly to have advanced at all. But none the less are they surely and steadily transpiring around us. In the fall of rain and the flow of rivers, in the bubble of springs and the silence of frost, in the quiet creep of glaciers and the tumultuous rush of ocean-waves, in the tremor of the earthquake and the outburst of the volcano, we may recognize the same play of terrestrial forces by which the framework of the continents has been step by step evolved. In this light the familiar phenomena of our daily experience acquire an historical interest and dignity. Through them we are enabled to bring the remote past vividly before us, and to look forward hopefully to that great future in which, in the physical not less than in the moral world, man is to be a fellow worker with God.—*Proceedings of the Royal Geographical Society.*

SERPENT-CHARM.

BY FELIX L. OSWALD, M. D.

THE pathology of spiritualism presents some curious parallels with that of a well-known class of physical disorders—the artificial derangements of the alimentary process by the opium-habit, and the abuse of alcoholic or pungent stimulants, which a French physiologist comprises under the name of toxicolatrous affections — the poison-manias, we might call them—and which, with all their characteristic causes, symptoms, progressive stages, direct and collateral effects, find their analogues in the half-voluntary delusion of ancient and modern miracle-mongers.

Spiritualistic as well as spirituous propensities can be transmitted by hereditary influences; both are liable to be aggravated by prolonged indulgence, to develop the symptoms of chronic diseases, and to end in hopeless delirium. The principal arguments against the use of poisonous stimulants are based upon their adventitious consequences. Dull headaches and red noses are mere trifles compared with the negative effects of habitual intoxication—loss of memory, energy, and self-respect, and of the relish for healthier food and all healthier and higher enjoyments. The worst of alcoholic blue-devils are the ghosts of departed hopes, for an unnatural passion implies many things, among which the hankering after a special kind of unwholesome stimulant is only a minor item.

For the same reason, it would be a mistake to suppose that the

mischief of anti-natural dogmas could be estimated by their direct effects—the propagation of a greater or smaller number of preposterous tenets; the chief bane of their influence is indirect and subjective, rather than objective. Not external facts only, but our own vision, they have obscured; the victims of supernaturalism have lost their critical faculty as well as their critical conscience—their standard of probability itself has been falsified. Like an all-pervading mist, the poison-vapor of mysticism has obscured the light of science, and blinded the eye of common sense to innumerable fallacies and charlatanries. St. Gregory Thaumaturgus is the patron-saint of all quacks—of mesmerists, fasting girls, blue glass and patent-medicine peddlers—as well as of indulgence-brokers. Mere dogma-worship might imply connivance, rather than blindness—a sort of *noli-me-tangere* awe more than insensibility; but also in scientific theorems where free inquiry is not only permitted but specially invited, the most obvious and palpable nonsense fails to be seen and felt. For people who have been fuddled with mysticism lose their relish for simple truth; the old *credo quod absurdum videtur* ("since it appears preposterous, I believe it") seems to be their motto.

A very characteristic instance of this abject credulity is the serpent-charm superstition. Millions of our countrymen still believe in what they call snake-charming; i. e., the ability of certain reptiles to paralyze smaller animals by the magic power of their *eyes*, a belief whose tenacity and extravagant absurdity nearly justify Pierre Gassendi's complaint that in regard to all occult phenomena the most supernatural theory is sure to become the popular one. Blacksnakes overtake their prey by superior swiftness and strangle them by superior strength; but the fact that such sluggish creatures as the Indian cobra and the American rattlesnake are able to capture birds and squirrels seemed to demand an abnormal explanation, and the demand, as usual, was equaled by the supply. Truth-loving and otherwise intelligent persons listen gravely to stories about linnets who hopped from branch to branch into the penetralia of a snake-infested bush, or swallows who paused in their headlong flight, hovered with tremulous wings for a minute or two, and then descended in a reluctant flutter toward a ditch or hedge where the enemy lay concealed, a coiled snake with a pair of twinkling optics that glittered like demons' eyes, while the doomed bird came nearer and nearer, and finally saved the serpent the trouble of swallowing it by hopping down its throat. The natives of our Southern coast States ascribe the same faculty to lizards and toads; and the darkeys of the Georgia river plantations, if asked to account for the frequent disappearance of sucking pigs, used to explain that they had been charmed away by alligators, who, without leaving their native element, were able to draw a pig clear across a ten-acre field by cocking their eyes in a peculiar way! But the arch-conjurer of our continent is still the sneaking rattlesnake, whose power for mischief is

thought to be hardly limited by the capacity of its stomach. Gratuitous malevolence, according to current stories, has often induced this symbol of the tempter to bewitch dogs and cattle, merely for the sake of testing the efficacy of its magic eyes first, and of its poison afterward; nay, a colored deacon of Navasota, Texas, affirms that he himself was once charmed by a flat-bellied rattlesnake, and favored the local weekly with a circumstantial account of his adventure. On his way home from meeting he took a short cut across a field (a sweet-potato field his neighbors suspect), and was just in the act of climbing a fence when his eye was caught by a piercing glitter in the weeds, a sudden, flash-like gleam that went through him like an electric shock, and made him grab the top rail with a convulsive grip. He tried to jump down, but could not; his legs were paralyzed, and a feeling of numbness began to creep up his body and toward his heart, while his eyes became so rigid that he could not even wink. He found that he could howl, which he did, with all his might; but, instead of being scared, the reptile wagged his tail, and came a little nearer. He gave himself up for lost, when he suddenly thought of a big prayer-book in his pocket, and in the moment when the serpent braced itself for a spring, he hurled at its head a copy of Baxter's "Saint's Rest" (Tract Society edition, 8vo), which, either by its weight or by its orthodox vigor, staggered the fiend for a second or two, during which the deacon effected his escape. The bird and squirrel stories are occasionally varied by a similar termination: the arrival of the witness broke the spell, and the squirrel hopped off, rejoicing; or the linnet perched upon the shoulder of the deponent, and twittered eloquently to express its gratitude for his timely intervention.

Only the insanity of the middle ages could excuse such superstitions; but that the subject has its difficulties is demonstrated by the variety of conjectures which have been offered for its elucidation. The serpent-charm fable has engaged the attention of different ancient and modern philosophers, but their treatment of the question is mostly what logicians call *anatreptic*, i. e., refuting without concluding anything in the affirmative, and the theories of professional zoölogists are somewhat inconsistent and unsatisfactory. Bichat speaks of a stupefying effluvium (*exhalaison hypnotique*) by which some reptiles benumb their victims; and Van der Hoeven suggests that the above-described suicidal infatuation of birds and rodents may be nothing but the well-known self-sacrificing courage of the nest-mothers in defense of their helpless brood; while some modern ophiologists (Keyserling, Cabanis, and Dr. Hitchcock) have rejected the idea that such sluggish reptiles as moccasins and rattlesnakes—unless assisted by accident or the artificial arrangements of captivity—could capture more agile animals than frogs or moles.

But the dissection of swollen rattlesnakes has revealed more feathers than moleskins, and the prairie moccasins of Kansas and Arizona would

have to crawl a long way before they could find a frog. In the sterile border-land of north Mexico and southern Texas swamps and frogs are hardly known to the untraveled natives, while the frequency of poisonous reptiles is almost unparalleled; and on a recent visit to the lower Rio Grande I found that the trade in living serpents, scorpions, and tarantulas has become a regular branch of industry, which in Cameron County, Texas, and Matamoras alone, employs a dozen professional and twenty or thirty juvenile amateurs. In a state of captivity these animals fast with the stoicism of an othodox fakir, so that the question of their proper diet becomes comparatively unimportant; but out in the prairie the *embonpoint* of the copperheads and yellow rattlesnakes suggests eupeptic habits and a liberal food-supply, though the arid soil yields neither frogs nor moles. Birds there are, in abundance; but how can the most subtle serpent secure them without incurring the suspicion of witchcraft? The opinions of the natives differ as widely as those of the above scientists. Among the less transcendental ones, some hold that the *vivoras* hunt in night-time, others that they poison the berries of the taxus-tree and surprise the birds while they are prostrated by a fit of gastritis. A rather intelligent *ranchero*, who had hauled a load of ice water and comestibles for a picnic party of American merchants and Mexican army officers, was present when the autopsy of an overgrown rattlesnake elicited a series of half-digested singing birds, and explained that the Rio Grande *vivoras* could only indulge in such luxuries since the establishment of the International Telegraph line, which caused the death of so many swift-flying birds that came in contact with the wires. This theory might satisfy the Spanish-American officers, but not an Anglo-American druggist, who had visited the upland prairies on his botanical excursions and had reasons to believe that the prosperity of the wily ophidians was not materially affected by the absence of telegraphic facilities. So he applied to one of the leading vivora-catchers and a week before my arrival in Matamoras obtained a pair of good-sized yellow rattlesnakes, which he added to a more or less happy family of lizards and blacksnakes in an empty room of his suburban cottage.

Reptilians, said he, are generally inexpensive boarders; his four lizards content themselves with a daily fly apiece, and one old horned toad has pursued the road of total abstinence to a length where even Dio Lewis would hesitate to follow; but some snakes make an exception: the *Coluber palustris*, or water-blacksnake, is almost insatiable, and the common blacksnake insists on his three daily meals with a firmness that would disgust the business-managers of a fasting girl. The rattlesnakes, too, began to crawl about and ply their tongues in a way that suggested a growing interest in the *table-d'hôte* arrangements of their new hotel, and cast furtive glances at a little mouse which had been introduced in anticipation of their wishes.

But, either through fastidiousness or a mistaken notion of duty to-

ward their fellow-lodgers, they tarried so long before they broke their fast that their host apprehended a dietetic misunderstanding, and treated them to a nest with five young sparrows the next day. Three of these died before their snakeships condescended to partake ; old sparrows, rats, and cockroaches were tried with no better success. The freckled ophidians still seemed to eat under protest, "yielding, but not consenting, to injustice," as Shere Ali said. But, though their proprietor's experiments failed to explain the mystery of rattlesnake-food, he believes that they solved a more interesting problem—the question in regard to the *modus operandi* of poisonous serpents in the capture of their prey.

During the first week of their confinement his rattlesnakes disdained to chase their game, and the stupidity of the bugs and young birds made it easy enough to collar them whenever they were wanted ; but one morning the *gamins* of the neighborhood caught an old blackbird and sold it to the zoölogical druggist for two pieces of stick-candy. The blacksnakes were covered up with an old apron to prevent their interference, and the *viboras* who had fasted for twenty-four hours, rather then eat cockroaches, got one more chance at a square meal. After fluttering around in an excited way for a while, the bird settled down in a corner, and the two snakes prepared for action. They lowered their heads, and, without moving the tail-end of their bodies, approached the bird by a gradual extension of their coils ; but he was all suspicion, and recommenced his fluttering before their cat-like advance had brought them within range. The snakes separated then ; the female rolled herself up in the blackbird's corner and her mate took post in the center of the room, but, after readjusting their coils, neither budged an inch ; they bided their time.

Dashing his head against the windows seemed to tire the bird after a while. Presently he came down, but alighted in a rather inaccessible place, took wing again, and, alighting in his old corner, finally blundered into the water-pot. He hopped out with drenched wings and devoted a few seconds to the rearrangement of his toilet, unconscious or heedless of the proximity of the female partner of the hostile alliance. She watched all his movements, and her tail quivered in a curious way when she saw him poke his head under his right wing, the one turned toward the corner ; she seemed to know that he would repeat the same manœuvre on the left-wing side. He did so, and she had him directly. Drawing herself up, she poised her neck like a dart, braced herself by contracting the rear coils, and let drive. A loud screech, a few feathers flying, and a terrified bird darting through the room like a blind chicken—cause and effect coinciding with shot-like suddenness.

Instead of following him she returned to her favorite nook, where she was soon after joined by her mate. The difficult part of the job was done. Three or four times the bird managed to take wing, stag-

gered around in a circle once or twice, and then sat still. The chemicals began to operate. First its legs and then its wings commenced to tremble ; trying to stand upright, it put its feet farther and farther apart and finally spread its wings, but to no purpose ; a convulsive tremor seized it, and with a gasp it fell over on its side ; and only at that moment did the snakes glide up to take possession of their prey. The same experiment was tried with a ground-squirrel and two half-grown chickens, and always with an analogous result. No animal likely to offer serious resistance was captured outright by the rattlesnakes. They managed to fetch it a bite and let it go, relying on the virus to do the rest.

Two causes conspire to make this the only practicable course for a moderate-sized reptile not gifted with the wildcat-like agility of the blacksnake. In the first place the fangs of a serpent are not rigid like those of a fox or shark, but movable and rather slender, and utterly unfit for seizing and holding struggling animals, excepting those of the smallest size. The poison-teeth of a rattlesnake are even retractile, and, being only attached to the palate by an elastic ligament, can be drawn backward by a temporal muscle, like the blade of a clasp-knife into its handle, and are too feeble to penetrate the skin of a tapir or hog, which animals attack and devour the most poisonous snakes with perfect impunity. With such teeth they can only administer a snap-bite.

On the other hand, the effect of the poison is never instantaneous : a man can walk two or three miles before his bitten leg begins to swell ; a snake-bitten dog can run for a couple of minutes without exhibiting any signs of uneasiness. A large bird may possibly fly away and out of sight, while even the smallest birds are able to take wing for a moment, and rats to make a dash toward their holes. The snakes know this, and bide their time with all the complacency of a veteran angler who holds a fish by a long line and permits it to exhaust its strength before he pulls home.

In the course of the countless ages during which men and serpents have been coinhabitants of this planet, it is not only possible but certain that some hunters or wood-cutters happened to witness the last act of an oft-repeated tragedy, the strange movements and subsequent convulsions of a bird or little rodent hopping, perhaps, in a helpless way around or even toward a snake that had watched it with glittering eyes. The first act they could only have seen indistinctly and from a distance, since their approach would have saved the victim by scaring it away in time. So they jumped at the conclusion that the *eyes* of the reptile had bewitched the poor creature, and found believers who would be very sorry to demolish such a delightfully mystic theory by prosaic investigations ; as for cognate reasons our spiritualistic contemporaries prefer to believe that the writing on the slate was produced by the " dear friend in the spirit-land," rather than

by the evaporation of sal enixum or muriate of ammonia; not because they are ignorant of the fact that minutes and hours may intervene between a cause and its visible effect, but because they yearn to substitute mystery for simple and intelligible truth. Not everybody could be expected to investigate the matter by expensive and laborious experiments, but all unmystified human beings could and should be able to foresee the result in regard to the main point, or suspend their opinion altogether rather than accept the enchantment theory. Not their poverty but their will consents. The witchcraft delusion had long been exposed in all its bottomless absurdity when people still believed in weather-wizards, were-wolves, and broomstick excursions through the chimney; and, after ninety-eight "mediums" have been caught *in flagranti*, the ninety-ninth can collect a roomful of grown-up persons who are kind enough to think it possible that disembodied souls could handle a fiddle-stick, or that flying beans and cherry-stones emanate from a spirit-popgun.

Venomous serpents would disappear without the aid of St. Patrick if they had to rely on the charm of their eyes for a dinner; for a rattlesnake, deprived of its chemicals, would starve as surely as a "magic slate-writing medium" in a like predicament.

NOVELTY IN PATENTS.

By OLIVER E. LYMAN.

BY the statute of 1870 it was enacted that an invention, to be patentable, must possess, among other qualifications, that of newness or novelty. But what constitutes novelty is not defined. The solution of the question is left to be determined according to the circumstances of each particular case. It is this fact which makes the question such a difficult one to be answered; for in each case there is generally some little element present which distinguishes it from other cases, and makes it impossible to frame one decided rule of universal application. The question is also rendered less easy of solution from the fact that it comes up most frequently in its most difficult aspect—in cases of infringement, where the point under discussion is, whether the alleged invention is, or is not, *substantially identical* with some prior existing thing, which has been in common use here or described in some patent or printed publication. Yet, despite the nicety in which this question of novelty is involved, we are not compelled to leave it entirely unsolved. A careful study of the subject discloses certain principles which by their application somewhat prune down the difficulty. We are fortunate in being able to approach the question from two sides; for, as was true in the case of the two-faced

shield, over which those two knights of old story wrangled so long, an inspection of the subject from two points of observation decidedly simplifies matters. The first of these methods of studying the subject I would designate the negative, and the second the positive method. By the negative method we deduce certain principles in regard to cases which have at first sight a color of novelty, but are not novel, so as to be patentable. By the positive method we arrive at certain conclusions in regard to what actually constitutes novelty in a patentable sense.

I propose to discuss, first: What cases, at first sight possessing novelty, do not actually possess novelty? A study of cases warrants us in accepting, as a first principle, that every change or mere substitution of a mechanical equivalent is not necessarily a patentable novelty; for it may not be substantially unlike some prior thing. We may have, for instance, a machine, comprising, say, three distinct parts. A man, not the inventor, substitutes for each of these parts other equivalents, producing the same results. This is not a patentable invention. Even if the products be better or cheaper, it is at most only an improvement upon a former invention, and can be used only with the permission of the former patentee.

I spoke above of a "mechanical equivalent." This needs to be defined in order that we may have a clear comprehension of the above principle. To define it, however, is not so easy. Mr. Parsons has said that "he would be a very acute man who could certainly discern, or a very bold man who would certainly assert, what is meant by a mechanical equivalent." At the risk of being considered bold, certain judges have, nevertheless, ventured to attack the Gordian knot. We find one definition in Smith *vs.* Downing, 1 Fisher's Patent Cases, 87: "By equivalents in machinery is usually meant merely the substitution of one mechanical power for another, or one obvious and customary mode for another, of effecting a like result." This definition is not sufficiently explicit. A better one is to be found in Carter *vs.* Baker, 4 Fisher's Patent Cases, 409: "When, in mechanics, one device does a particular thing, or accomplishes a particular result, every other device *known* and *used* in mechanics, which skillful and experienced workmen know will produce the same result, or do the same particular thing, is a known mechanical substitute for the first device mentioned for doing the same thing, or accomplishing the same result. It is sufficient to constitute a known mechanical substitute that, when a skillful mechanic sees one device doing a particular thing, he knows the other device, whose uses he is acquainted with, will do the same thing."

This definition not only covers those elements which come strictly under the head of mechanics, but is also our guide in determining what constitutes an equivalent in an "art," or a "manufacture," or a "composition of matter." The definition of an equivalent of any substance in a composition made of several ingredients, for example, is, in

accordance with our guide, any other substance having similar properties and producing substantially the same effect.

So much for the first class of cases, which at first sight are apparently novel, but which in reality are not novel, so as to be patentable.

Another class of cases against which the verdict of "no novelty" must be pronounced is where a new use is made of an old invention. This is no new invention. The mere application of an old invention or means or method of operation to a new use does not amount to a patentable novelty. There is nothing new made by such a proceeding. The use of the thing is perhaps enlarged and that is all. It was upon this principle that adverse decisions were rendered to the claimants in the cases of Losh *vs.* Hague, and Howe *vs.* Abbott. In the first of these, which is reported in 1 Webster's Patent Cases, 205, it was held that the application to railway-carriages of a kind of wheel previously in use on common carriages would not support a patent. In the second case, which is reported in 2 Story, 190, the patentee claimed as his invention a process of curling palm-leaf for mattresses. It appeared from the evidence that horse-hair had for a long time been prepared by the same process and devoted to the same purpose. In delivering his opinion Judge Story said: "The application of an old process to manufacture an article to which it had never before been applied, is not a patentable invention. There must be some new process or some new machinery used to produce the result. . . . He who produces an old result by a new mode or process is entitled to a patent for that mode or process. But he can not have a patent for a result merely without using some new mode or process to produce it."

Allied to this question of double use is the question whether a patent can be taken for a particular use of a known machine, when the plaintiff is the first to discover the benefit of such use. As may be supposed, from the place in which I have inserted this question, the answer is "No." And there is justice in the answer; for a man is entitled to all the benefit of an article which he has invented and patented. The man who happens to discover an additional use to which the invention may be applied does not by that discovery and application create a patentable novelty. He devises no new combination of machinery, no new process. Hear what Lord Chelmsford said on the subject. His opinion is to be found in Ralston *vs.* Smith, 11 H. L. C., 256. In this case, by the way, the plaintiff had discovered that by giving a differential motion to different parts of an old machine, a power existing in it might be developed and brought into action. Lord Chelmsford, after stating that he saw no new process, or new combination of machinery, said, "It appears to me that such a discovery is not the subject of a patent." And the same doctrine is laid down in the case of Tetley *vs.* Easton, 2 C. B. (N. S.), 706.

There is another class of cases which demands attention. It sometimes happens that a man seeks a patent for a mere aggregation of

things—as, for example, a hammer with a screw-driver inserted in one end of the handle and an awl in the other. The absurdity of granting a patent in such a case is very apparent, and it is no wonder that in the case of Swift *vs.* Whizen, 3 Fisher's Patent Cases, 357, a decision was given against the patentability of the very aggregation given above as an example.

A distinction should be made between such aggregations, when the whole is easily divisible into its component parts, and aggregations where the individuality of the component parts is lost. I would revert to the hammer and screw-driver as an example of what I mean by the divisibility of the whole. The hammer can be taken by itself, the awl by itself, and the screw-driver by itself, and used. As an example of what I mean by the loss of individuality, take the combined glass-cutter, screw-driver, can-opener, etc., which have been on sale in the streets of late. Here there is but one invention in reality, and the various parts are merged in one whole. The novelty lies in the new combination of the glass-cutter, can-opener, etc., in such a way that the utility of the parts would be lost by division.

We have now left to discuss the general rule that a mere alteration in the form, size, material, or proportions of an existing device is not such a change as to produce patentable novelty. This rule is related to the first one given in regard to the substitution of mechanical equivalents, but it is much wider in its scope. It is laid down in express terms in the second section of the act of February 21, 1793. This declaratory law was not reënacted in the patent act of 1836, yet necessity and justice compel its recognition. For, as was said in Winans *vs.* Denmead, 15 Howard, 341: "It is a principle which necessarily makes part of every system of law granting patents for new inventions. Merely to change the form of a machine is the work of a constructor, not of an inventor; such a change can not be deemed an invention."

A very interesting case on this point is reported in 11 Howard, 248 (Hotchkiss *vs.* Greenwood). It relates particularly to the substitution of a new material. In this case a new clay knob was substituted for a metallic knob. It was claimed that there was a patentable novelty. But there was no new mechanical device or contrivance. The knob was not new. The metallic shank and spindle were not new; nor the dovetail form of the cavity in the knob, nor the means by which the metallic shank was securely fastened therein. The only change was in the substitution of a clay for the former metallic knob. Judge Nelson very properly decided that there was no such novelty in this as to warrant the granting of a patent. "This of itself," said he, "can never be the subject of a patent. No one will pretend that a machine, made in whole or in part of materials better adapted to the purpose for which it is used than the materials of which the old one is constructed, and for that reason better and cheaper, can be dis-

tinguished from the old one; or, in the sense of the patent law, can entitle the manufacturer to a patent."

So much for the negative method of investigation of the subject of novelty in patents. We have discussed many cases of apparent novelty and have seen in what novelty does *not* consist. In accordance with the old saw, "You tell me what you're *not*, and I'll tell you what you are," we are now prepared to turn to what I have called the positive method of investigation and learn what *is* patentable novelty.

To answer the question, What is novel, so as to be patentable? is easier than the one we discussed in the first part of this paper. In a few words, there is patentable novelty when there is a different principle of operation; when there is a different result in kind, or when there is a new combination. It is for one or another of these reasons that a patent is ever granted. There may be other grounds apparently, but a closer investigation will show them to be but another species of the above family, and consequently to be classified with them in their application.

The first two of the three principles enumerated can best be treated of together. To repeat, there will be novelty when either the manufacture produced, or the manner of producing an old one is new. In the former case there must be something *substantially* new, different from what was before known. In the latter case the principle of the machine must be different. And, as I have shown before, a mere change of the form or proportions will not suffice, if both are the same in principle, structure, mode of operation, and produce the same result. This is true even if there is some small variance in some small matter for the purpose of evasion, or a color for a patent. There must be some principles different from any previously known.

This opens up the ancillary and important question, What is meant by "the principles of a machine"?

In Whittemore *vs.* Cutter, 1 Gall., 478, Judge Story says: "By the principles of a machine is not meant the original elementary principles of motion which philosophy and science have discovered, but the *modus operandi*, the peculiar manner or device for producing any given effect. If the same effects are produced by two machines by the same mode of operation, the principles of each are the same. If the same effects are produced, but by combinations of machinery operating substantially in a different manner, the principles are different."

In deciding whether the principles of a machine are new, there is one block over which we may stumble and which we should take care to avoid. There is danger of confusing form with principle. The question of what constitutes form and what principle is frequently a very nice question to decide. Judge Washington, in Treadwell *vs.* Bladen, 4 Wash., 706, has pointed out a road out of the confusion. "The safest guide," says he, "to accuracy in making the distinction is, to ascertain what is the result to be obtained by the discovery; and

whatever is essential to that object, independent of the mere form and proportions of the thing used for the purpose, may generally, if not universally, be considered as the principle of the invention."

The third principle above enumerated, that a new combination is a patentable novelty, is well elucidated in the case of Barrett *vs.* Hull, 1 Mass., 474. This was a case for the infringement of a patent granted for "a new and useful improvement, being a mode of dyeing and finishing all kinds of silk-woven goods." Judge Story said: "A patent may be for a new combination of machines to produce certain effects; and this whether the machines constituting the combination be new or old." And in Whitney *vs.* Emmett, 1 Baldwin, 311, also the patentability of a new combination was upheld. What the learned Judge said is so good an epitome of all that has been said in the second part of this paper, that I give it, although it is merely cumulative:

"Novelty consists in producing a new substance, or an old one in a new way, by new machinery, or a new combination of the parts of an old one, operating in a peculiar, better, cheaper, or quicker method, a new mechanical employment of principles already known."

The rule in regard to new combinations, as above laid down, is most just, for the most valuable inventions consist in the combination of known mechanical powers. It makes no matter if some of the elements are old (McCormick *vs.* Talcott, 20 Howard, 405); nor even if every part of such invention can be found in some form or other among the many devices of human ingenuity. As was said in Pitts *vs.* Edmond, 2 Fisher's Patent Cases, 55, "The man who unites these powers and produces a new and important result to society is well denominated a public benefactor."

There is one important principle in regard to combinations which, although not bearing directly upon the question of novelty, yet ought to be remembered. Judge Story called attention to it in the preceding case of Barrett *vs.* Hull: "It is no infringement," he said, "of the patent to use any of the machines *separately*, if the *whole combination* be not used, for in such case the thing patented is not the separate machines, but the combination."

With this quotation I end the discussion of the question of novelty in patents. I have endeavored to make my answer as satisfactory as the difficulties of the question would allow. I have for that purpose viewed the subject from two standpoints of opposite natures and have enumerated and discussed certain principles of general application which were disclosed by this double observation. The work must at the best, however, be incomplete, for, as Mr. Parsons says, "It is obviously impossible to find precise and technical rules which always answer the question."

DEVELOPMENT OF THE HOUSE-FLY.

By M. H. ROBSON.

THE following remarks on the development of the house-fly are based on actual observation, and the appended sketches were made by Mr. G. Harkus from the microscope, with the aid of a Beales reflector.

Mr. Harkus, with whom I experimented simultaneously, was fortunate, or the reverse, in having the required ova brought to him in this way: A fly having gained access to a cold joint of lamb considerately left a sufficient supply for his examination. The objectionable part of the arrangement was probably counterbalanced by his being enabled to fix the time of deposition with tolerable certainty. This was on July 28th. The eggs (one of which is represented in Fig. 3, its diameter one thirtieth of an inch) were placed with a portion of the meat in a glass vessel, and next day the maggots had emerged as in Fig. 4 (diameter one twenty-fifth of an inch), where the ramifications of the tracheal system may be traced.

The warm weather, coupled with the indoor heat, matured the larva rapidly, the change from maggot to chrysalis (Fig. 2) being apparent at each observation, some having assumed this state on July

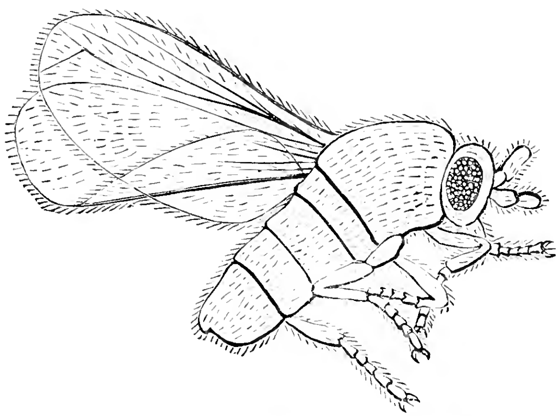

Fig. 1.—The House-Fly (*Musca domestica*), magnified.

30th. The perfect stage was reached and the fly emerged on August 5th, or eight days from the deposition of the ova (Fig. 1).

This was a week in advance of the result obtained in my experiment, which I preferred to conduct out of doors. A piece of raw liver was exposed, which soon had eggs enough attached to it. It would appear that the fly has to some extent the power of withholding the

deposition of her ova until a suitable medium is found for the requirements of the larva.

In two or three days the maggots were at work; their activity and voracity in devouring the putrescent mass of animal matter gave it the appearance of fermentation.

For observation in the live box, any little weakness connected with the somewhat objectionable odor arising from the garbage had to be got rid of and some few maggots washed clean. Neither immersion in water nor yet compression seemed to inconvenience them appreciably;

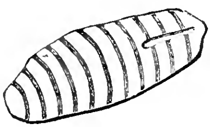

Fig. 2.—Chrysalis of House-Fly, July 20, 1878, × 40.

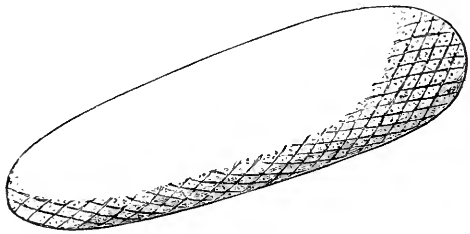

Fig. 3.—Egg of House-Fly, July 28, 1878, × 30.

their leathery integument is not easily ruptured, and is sufficiently translucent to render the trachea, as well as the undulatory vermicular movement of the internal organs, apparent throughout under a low power; in fact, from its toughness, transparency, and strength, the larva is an excellent object for microscopic examination. When the animal matter was devoured, the maggots moved restlessly about, changing in color from yellowish-white to brownish-red; the cuticle became dense and opaque; motion gradually ceased, until the perfect insect emerged by forcing of the segments of the anterior end of the shell, occupying from fourteen to fifteen days in completing its series of life-changes.

Mr. Harkus's part of the experiment appears to be useful so far as to show the adaptability of the fly and its ova to circumstances, and that the larva assumes the chrysalid state when its supply of food becomes exhausted, although otherwise immature (in this case the animal matter given them would dry up), instead of dying from starvation.

The chrysalis and fly in his examples are undersized and impoverished, compared to those permitted to feed in a semi-fluid mass of animal matter.

In autumn the house-fly seems specially the victim to the attacks of a parasitic fungus (*Empusa muscæ*), and may be seen glued, as it were, to walls, a white powdery growth appearing at the segments of its body (the spores of the fungus). This vegetable pest is similar to, if not identical with, the parasite which causes so much destruction among fish in aquariums, and last year even attacked salmon in some English rivers.

The cause of the fly becoming so firmly attached to dry surfaces is this: The two pulvilli which, with two strong curved claws (perhaps best seen with the flesh-fly, *Musca vomitoria*, as a subject), terminate

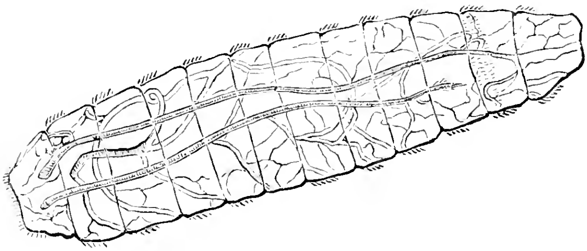

FIG. 4.—MAGGOT OF HOUSE-FLY, July 29, 1878, × 25.

the foot, are surrounded by a fringe of tubular hairs, each ending with a disk or sucker, through which a glutinous fluid exudes. These form the points of attachment, enabling the insect to walk in any position, the action of the two claws detaching these points as the fly moves along.

When the ravages of the parasite have sufficiently weakened the fly by the destruction of its viscera, etc., it becomes incapable of active movement, and, remaining too long in a place, the viscid fluid continues to exude, and then the fly "sticks to the wall."—*Science Gossip*.

FOOD AND FEEDING.

BY SIR HENRY THOMPSON.

III.

I HAVE already said that, among all civilized nations, wine in some form has for centuries been highly appreciated as a gastronomic accompaniment to food. I can not and do not attempt to deny it this position. Whether such employment of it is advantageous from a dietetic or physiological point of view is altogether another question. I am of opinion that the *habitual* use of wine, beer, or spirits is a dietetic error, say, for nineteen persons out of twenty. In other words, the great majority of the people, at any age or of either sex, will enjoy better health, both of body and mind, and will live longer, without any alcoholic drinks whatever, than with habitual indulgence in their use, even although such use be what is popularly understood as moderate. But I do not aver that any particular harm results from the habit of now and then enjoying a glass of really fine, pure wine—and, rare as

this is, I do not think any other is worth consuming—just as one may occasionally enjoy a particularly choice dish; neither the one nor the other, perhaps, being sufficiently innocuous or digestible for frequent, much less for habitual use. Then I frankly admit that there are some persons—in the aggregate not a few—who may take small quantities of genuine light wine or beer with very little if any appreciable injury. For these persons such drinks may be put in the category of luxuries permissible within certain limits or conditions; and of such luxuries let tobacco-smoking be another example. No one probably is any better for tobacco; and some people are undoubtedly injured by it; while others find it absolutely poisonous, and can not inhale even a small quantity of the smoke without instantly feeling sick or ill. And some few indulge the moderate use of tobacco all their lives without any evil effects, at all events that are perceptible to themselves or to others.

Relative to these matters, every man ought to deal carefully and faithfully with himself, watching rigorously the effects of the smallest license on his mental and bodily states, and boldly denying himself the use of a luxurious habit if he finds any signs of harm arising therefrom. And he must perform the difficult task with a profound conviction that his judgment is very prone to bias on the side of indulgence, since the luxurious habit is so agreeable, and to refrain therefrom in relation to himself and to the present opinion of society, so difficult. Be it remarked, however, that the opinion of society is notably and rapidly changing relative to the point in question.

Having premised thus much, I have only now to say, first, that wine, in relation to dinner, should be served during the repast; it should never be taken, in any form or under any circumstances, before, that is, on an empty stomach, and rarely after the meal is finished. Regarded from a gastronomic point of view alone, nothing should appear after fruit but a small glass of cognac or liqueur, and coffee. The postprandial habit of drinking glass after glass even of the finest growths of the Gironde, or of the most mature or mellow shipments from Oporto, is doubtless a pleasant, but, in the end, for many persons, a costly indulgence.

Secondly, whatever wine is given should be the most sound and unsophisticated of its kind which can be procured. The host had far better produce only a bottle or two of sound *bourgeois* wine from Bordeaux—and most excellent wine may be found under such a denomination—with no pretense of a meretricious title, or other worthless finery about it, than an array of fictitious mixtures with pretentious labels procured from an advertising cheap wine-house. I could only speak in terms of contempt and disgust, did I not feel pity for the deluded victims, of the unscrupulous use of the time-honored and historical titles which advertisers shamelessly flaunt on bottles of worthless compounds by means of showy labels, in lists and pamphlets

of portentous length, and by placards sown broadcast through the country. So that one may buy "Lafite" or "Margaux"—"Chambertin" or "Nuits"—'47 port, or even '34—at any village store! No terms can be too strong to characterize such trade.

If fine wines of unquestionable character and vintage are to be produced, there are only two ways of possessing them: one, by finding some wine-merchant of long standing and reputation who will do an applicant the favor to furnish them, and the price must be large for quality and age. We may be certain that such a one will never advertise: no man who really has the *grands vins* of esteemed vintages in his cellar need spend a shilling in advertisements, for he confers a favor on his customer by parting with such stock. But better and more satisfactory is it to obtain from time to time a piece or two of wine, of high character and reputed vintage, when they are to be had, just fit to bottle, and lay them down for years until ripe for use. Commencing thus in early life, a man's cellar becomes in twenty or thirty years a possession of interest and value, and he can always produce at his little dinners, for those who can appreciate it, something curiously fine, and free at all events from the deleterious qualities of new and fictitious wines.

Briefly: the rule, by general gastronomic consent, for those who indulge in the luxury of wine, is to offer a glass of light pale sherry or dry Sauterne after soup; a delicate Rhine wine, if required, after fish; a glass of Bordeaux with the joint of mutton; the same, or champagne—dry, but with some true vinous character in it, and not the tasteless spirit-and-water just now enjoying an evanescent popularity—during the *entrées;* the best red wine in the cellar, Bordeaux or Burgundy, with the grouse or other roast game; and—but this ought to suffice, even for that exceptional individual who is supposed to be little if at all injured by "moderate" potations. With the ice or dessert, a glass of full-flavored but matured champagne, or a liqueur, may be served; but at this point dietetic admonitions are out of place, and we have already sacrificed to luxury. The value of a cigarette at this moment is that with the first whiff of its fragrance the palate ceases to demand either food or wine. After smoke the power to appreciate good wine is lost, and no judicious host cares to open a fresh bottle from his best bin for the smoker, nor will the former be blamed by any man for a disinclination to do so.

For unquestionably tobacco is an ally of temperance; certainly it is so in the estimation of the gourmet. A relationship for him of the most perfect order is that which subsists between coffee and fragrant smoke. While wine and tobacco are antipathetic, the one affecting injuriously all that is grateful in the other, the aroma of coffee "marries" perfectly with the perfume of the finest leaf. Among the Mussulmans this relationship is recognized to the fullest extent; and also throughout the Continent the use of coffee, which is almost symboli-

cal of temperate habits, is intimately associated with the cigarette or cigar. Only by the uncultured classes of Great Britain and of other northern nations, who appear to possess the most insensitive palates in Europe, have smoke and alcoholic drinks been closely associated. By such, tobacco and spirit have been sought chiefly as drugs, and are taken mainly for their effects on the nervous system—the easy but disastrous means of becoming stupid, besotted, or drunk. People of cultivated tastes, on the other hand, select their tobacco or their wines, not for their qualities as drugs, but for those subtler attributes of flavor and perfume, which exist often in inverse proportion to the injurious narcotic ingredients ; which latter are as much as possible avoided, or are accepted chiefly for the sake of the former.

Before quitting the subject of dining it must be said that, after all, those who drink water with that meal probably enjoy food more than those who drink wine. They have generally better appetite and digestion, and they certainly preserve an appreciative palate longer than the wine-drinker. Water is so important an element to them, that they are not indifferent to its quality and source. As for the large class which can not help itself in this matter, the importance of an ample supply of uncontaminated water can not be overrated. The quality of that which is furnished to the population of London is inferior, and the only mode of storing it possible to the majority renders it dangerous to health. Disease and intemperance are largely produced by neglect in relation to these two matters. It would be invidious, perhaps, to say what particular question of home or foreign politics could be spared, that Parliament might discuss a matter of such pressing urgency as a pure water-supply ; or to specify what particular part of our enormous expenditure, compulsory and voluntary, might be better employed than at present, by diverting a portion to the attainment of that end. But for those who can afford to buy water no purer exists in any natural sources than that of our own Malvern springs, and these are aerated and provided in the form of soda and potash waters of unexceptionable quality. Pure water, charged with gas, does not keep so long as a water to which a little soda or potash is added ; but for this purpose six to eight grains in each bottle suffice—a larger quantity is undesirable. All the great makers of these beverages have now their own artesian wells or other equally trustworthy sources, so that English aerated waters are unrivaled in excellence. On the other hand, the foreign *siphon*, made, as it often is, at any chemist's shop, and from the water of the nearest source, is a very uncertain production. Probably our traveling fellow countrymen owe their attacks of fever more to drinking water contaminated by sewage matter than to the malarious influences which pervade certain districts of southern Europe. The only water safe for the traveler to drink is a natural mineral water, and such is now always procurable throughout Europe, except in very remote or unfrequented

places.* In the latter circumstances no admixture of wine or spirit counteracts the poison in tainted water, and makes it safe to drink, as people often delight to believe; but the simple process of boiling it renders it perfectly harmless; and this result is readily attained in any locality by making weak tea, to be taken hot or cold; or in making toast-water, barley-water, lemonade, etc. The table-waters now so largely imported into this country from Germany and France contain a considerable proportion of mineral matter in solution, and, while they are wholesome as regards freedom from organic impurities, are, of course, less perfect for daily use than absolutely pure waters, such as those above referred to. Vaunted frequently as possessing certain medicinal properties, this very fact ought to prohibit their constant use as dietetic agents for habitual consumption, inasmuch as we do not require drugs as diet, but only as occasional correctives. Among them, the natural Selters, Apollinaris, Gieshübel, and St. Galmier—but of this latter some of the sources are inferior to others, the best appearing now to be chiefly retained for Paris—are perhaps among the most satisfactory within our reach. A dash of lemon-juice and a thin cutting of the peel form sometimes an agreeable addition. I am compelled to say that the sweet compounds and fruity juices which have of late been produced as dinner-drinks, and apparently in competition with wine, are rarely wholesome adjuncts to a dinner. Such liquids rapidly develop indigestible acid products in the stomachs of many persons; while, for all, the sipping of sweet fluids during a meal tends to diminish appetite, as well as the faculty of appreciating good cookery. If wine is refused, let the drink be of pure water—with a sparkle of gas in it, or a slight acid in it if you will—but in obedience both to gastronomic and dietetic laws let it be free from sugar. No doubt there are exceptional circumstances in which fruity juices, if not very sweet, can be taken freely. Thus I have rarely quaffed more delicious liquor at dinner in the warm autumn of southern Europe, notably in Spain, than that afforded by ample slices of a watermelon, which fill the mouth with cool, fragrant liquid; so slight is the amount of solid matter, that it only just serves to contain the abundant, delicate juices of the fruit grown in those climates. Here the saccharine matter is present only in small proportion.

Before concluding, a remark or two may be permitted in reference to that great British institution, the public dinner. Its utility must, I suppose, be conceded, since, for a vast number of charitable and other interests, the condition of commanding once a year the ear of the British public for an exposition of their claims seems in no other way at

* Throughout France, St. Galmier; in Germany, Selters; in Austria and Bohemia, Gieshübel, are always obtainable, being the table-water of most repute, in each case respectively, of the country itself. In all chief places in Italy, either Selters or St. Galmier, often both, are supplied by the hotels. In Spain, these are not at present to be had, but the alternatives recommended are easily obtained.

present attainable. A royal or noble chairman, a portentous *menu*, an unstinted supply of wine, such as it is, and after-dinner speeches, in variety, form an *ensemble* which appears to be attractive to the great body of "supporters." On the other hand, those whose presence is enforced by the claim of duty find these banquets too numerous and too long. The noise and bustle, the badly-served although pretentious dinner, the glare of gas and the polluted air, the long, desultory, and unmeaning speeches, interspersed with musical performances—which, however admirable in themselves, extend unduly a programme already too comprehensive—unfit many a man, seriously occupied, for the engagements of the morrow. Might it not be worth trying the experiment of offering fewer dishes, better service, and abolishing half the toasts? Might it not be possible to limit the necessary and essential toasts of a public dinner to the number of three or four—these to be followed only by a few subordinate toasts associated with the minor interests of the special object of the dinner? With the utmost deference to long-received usage, and after some little consideration, I venture to suggest that the following programme would at all events be an improvement on the present system, if such it can be called:

The first toast, or toasts, by which we declare our fidelity to the Crown, and our loyalty to the person of the Sovereign, as well as to the royal family, to remain, by universal consent, as before. The next, or patriotic toasts, unlike the preceding, are regarded as demanding response, often from several persons, and here it is that time is generally wasted. These might therefore be advantageously compressed into one, which need not be limited to the military and naval services, although it would of course include them. The object might be attained by constituting a single comprehensive but truly patriotic toast, viz., "Our great national institutions," which are easily defined. Supposing them to be regarded as seven in number, a response might be provided for from any two, according to the speakers present and the nature of the special object. These institutions fall naturally into order, as—1. Parliament: its leaders. 2. Justice: the judges. 3. The military and naval forces: their officers. 4. Education: heads of universities and public schools. 5. Religion: its ministers. 6. Science and art: heads of societies, academies, colleges. 7. Literature and the Press: distinguished writers.

The next to be "the toast of the evening": in other words, the particular subject of the dinner. After this would follow the healths of officers connected with the subject, visitors, etc., if necessary.

I confess I see no reason why the military and naval forces, however profound our respect and our gratitude for their great services to the nation must be—and in this matter I yield to no man—should invariably occupy a toast and speech, to be responded to by at least two, often by three officers, while the other great and scarcely less important interests should be left out of consideration altogether, or

be only occasionally introduced. The toast of "national institutions" would mostly insure to the chairman and managers of the dinner an opportunity of obtaining two good speakers from different interests in reply—say, one for Justice and the other for Religion; one for Parliament or the Services, and the other for Science or Literature, and so forth. Thus all the varied elements of our national life would receive in their turn a due share of attention from the great mass of public diners, and better speeches would probably be secured than by the present mode.

I confess this is rather an episode; but the subject of "toasts" is so interwoven with the management of the public dinner that I have ventured to introduce it. I even dare to think that the proposition may be not unlikely to receive the support of "the chair," the duties of which, with a long array of toasts, are sometimes excessively onerous; only more so, be it recollected, in degree than those, of a humbler kind, which are entailed on many of the guests who are compelled to assist.

In concluding this imperfect sketch of the very large subject indicated by the title of my paper, I desire to express my strong sense of its manifold shortcomings, especially by way of omission. Desiring to call attention, in the shortest possible compass, to a great number of what appear to me to be important considerations in connection with the arts of selecting, preparing, and serving food, I have doubtless often failed to be explicit in the effort to be brief. It would have been an easier task to illustrate these considerations at greater length, and to have exceeded the limits of a couple of articles; and I might thus perhaps also have avoided, in dealing with some topics, a tone in statement more positive than circumstances may have warranted. Gastronomic tastes necessarily differ, as races, habits, digestive force, and supplies of food also differ; and it becomes no man to be too dogmatic in treating of these matters. *De gustibus non est disputandum* is in no instance more true than in relation to the tastes of the palate. Still, if any rational canons are to be laid down in connection with food and feeding, it is absolutely necessary that something more than the chemical and physiological bearings of the subject should be taken into consideration. With these it is unquestionably essential for any one who treats of my subject to be familiar; but no less necessary is it to possess some natural taste and experience in the cultivation of the gustatory sense; just as a cultivation of the perception of color and a sensibility to the charm of harmoniously combined tints are necessary to an intelligent enjoyment of the visual sense and to the understanding of its powers. Hence the treatment of the whole subject must inevitably be pervaded to some extent by the personal idiosyncrasy and predilections of the individual. It is this fact, no doubt, which, operating in relation to the numerous writers on cookery, has tended to produce some of the com-

plication and confusion which often appears in culinary directions and receipts. But the gastronomic art is a simpler one than the effusions of some of its professors might lead the wholly uneducated to believe; and the complicated productions originated by some of its past and greatest practitioners are as unnecessary as are the long and complicated prescriptions formerly in vogue with the leading physicians of past time. Both were the natural outgrowth of an age when every branch of technical education was a "mystery," and when those who had attained the meaning thereof magnified their craft in the eyes of the vulgar by obscuring what is simple in a cloud of pedantic terms and processes. But that age and its delusions are passing away, and it is high time for simplicity in the practice of cookery to take the place of some useless and extravagant combinations and treatment which tradition has handed down.

At the present day it appears desirable, before all things, to secure the highest quality of all produce, both animal and vegetable; a respectable standard being rarely attained throughout our country in regard to the products of the latter kingdom. Great Britain has long held, and still maintains, the first place as to quality for her beef and mutton; in no other country in Europe—I can not speak of America—is it possible to obtain these meats so tender, juicy, and well developed. The saddle, the haunch, the sirloin, and the round, so admirable on occasions, are only in danger of suffering here, like intimate friends, from too great familiarity with their charms. But even our standard of quality in meat has been gradually lowered, from the closer struggle, year by year, to produce a fat animal in a shorter space of time than formerly; a result which is accomplished by commencing to feed almost exclusively on oil-cake at a very early period of life. The result of this process is, that size and weight are attained by a deposit of fat, rather than by the construction of muscular fiber, which alone is true meat; while, as a necessary consequence, the characteristic flavor and other qualities of fully developed beef and mutton are greatly wanting in modern meat.

Much more unsatisfactory is the supply of vegetable and dairy produce to our great city, particularly of the former. It must be confessed that our market at Covent Garden, in relation to capabilities for effective distribution of fresh vegetables, etc., would disgrace a town one fifth of the size of London. Nineteen twentieths of its inhabitants can not obtain fresh green food on any terms, and those who succeed pay an exorbitant price. I think I am right in saying that a really new-laid egg is a luxury which a millionaire can scarcely insure by purchase; he may keep fowls, and with due care obtain it, not otherwise. The great staple of our bread, commonly called "baker's bread," is unpalatable and indigestible; and I suppose no thoughtful or prudent consumer would, unless compelled, eat it habitually—used as it nevertheless is by the great majority of the inhabitants of this

great city—any more than he would select a steak from the coarse beef whose proper destination is the stock-pot. Let any one compare the facilities which exist in most foreign towns for obtaining the three important articles of diet just named, with the parallel conditions afforded by London, and the inferiority of the latter will be so manifest as to become matter of humiliation to an Englishman. I do not raise any question of comparison between our own markets and the Halles Centrales of Paris, covering as they do nearly five acres of closely utilized space, with enormous vaults beneath, in direct communication by tram-road with the railways; nor of the well-stocked Marché St. Honoré, and others of less note. To many among the thousands of tourists who frequent the public buildings of Paris, an early morning survey of the fish, flesh, dairy produce, vegetables, fruit, and flowers, which the Halles Centrales display, and the scarcely less remarkable exhibition of Parisian and provincial life brought together there, present one of the most interesting and truly foreign spectacles which the city affords.

To the long list of needed reforms I have ventured to advocate in connection with this subject, I must add the want of ample and accessible markets in various parts of London, for what is known as country produce. I do this not only in the interest of the millions who, like myself, are compelled to seek their food within the limits of Cockayne; but also in the interest of our country gardeners and housewives, who ought to be able to supply us with poultry, vegetables, and eggs, better than the gardeners and housewives of France, on whom at present we so largely depend. We may well be grateful to these small cultivators, who by their industry and energy supply our deficiencies; but the fact that they do so does not redound to the credit of our countrymen.

No doubt, as regards security, liberty, locomotive facilities, etc., Cockayne is a tolerably comfortable and pleasant place to live in; nevertheless, it is certainly true that greater intelligence, more enterprise, and better organization—perhaps of the coöperative kind—are much required, in order to improve not only the sources and quality of our food, but also some of our manners and customs in relation to selecting, preparing, and serving it.—*Nineteenth Century.*

A REMARKABLE COINCIDENCE.

LETTER FROM DR. GEORGE M. BEARD.

To the Editors of the Popular Science Monthly:

IN the April number of your Journal for this year (1879), I discussed the subject of coincidences as one of the six sources of error in experimenting with living human beings, and stated in substance that this department of logic had been most imperfectly studied, and that the

mathematical doctrine of chances especially had been abused and misunderstood, to the great detriment of science.

The following very remarkable correspondence illustrates my position so forcibly that I beg leave to present it to your readers.

The first letter is a so-called "April-fool" letter, as the date suggests, and is wholly imaginative. It was written for amusement purely, and obtained a very different reply from what was expected.

The author of the communication is a well-known merchant of this city, and a friend of mine. The person who replied is also well known in the region where he resides.

This coincidence is certainly one of the most remarkable of any recorded in the history either of logic or of delusions.

202 Columbia Heights, Brooklyn,
April 1, 1879.

My dear Sister Velina: You will no doubt be somewhat surprised to receive a letter from me, but I have a little matter of business, and if you will attend to it you will place me under obligations to your good self.

Some time ago a man by the name of John Nasium lived in New York. His father was a Southerner, and died last summer of yellow fever. He had two brothers, James and George. The former, some years ago, went to California, and the latter, I understand, resides somewhere in Kansas.

This John Nasium seems to have been the black sheep of the family, and when he left New York he did not leave a very good record behind him. He went from here to Toledo, Ohio, and afterward, we hear, he went to Tecumseh, Michigan, no doubt thinking that in a quiet country place he would be more secluded than he could be in a city. I and several of my friends would like to get track of him, if it can be done quietly, and without exciting any suspicion. He may have changed his name, and so I will describe the man, as nearly as I can, which may be some help to you. John I never knew very well, but his brother Jem, as they called him here, I knew very well indeed. John is rather tall, weighing about 180 pounds, I should think. He stoops a little, and is slightly lame in the left leg. You would not observe his lameness unless you were to pay particular attention to him while walking. His hair is a dark sandy color, in fact almost a red, and his side-whiskers are almost the same color, but a little darker. He is about thirty-eight years of age, but really does not look over thirty. His eyes are a very dark brown, and the left eye looks a little peculiar, i. e., unlike the other—looks as if some time or another a cataract had been removed by an operation. To look at him, you would at once see a difference in his eyes, and yet I can not describe the difference any better than I have done. While he lived here he usually wore his hair rather long, and carried himself in a style peculiar to the Southerner.

Now, perhaps the best and most prudent way for you to do would be for you to go up and read this letter to Uncle Hiram first. He is a very careful, discreet man, and he can make inquiries and excite less suspicion than you could.

I am real sorry to make you any trouble, and much less Uncle Hiram, but this is a matter, if it can be properly done, which may be of considerable importance to me and several of my friends, and perhaps further the ends of justice.

There is one other mark which may aid you, which is—this man was in the rebel army, and *his forefinger on his left hand was shot off.* His nose is quite

prominent, and he has a very mild and quiet look, and he is the last man you would pick out for the scoundrel that he is. Yours very truly,

R. T. Bush.

P. S.—Please attend to it, and oblige.

Shortly after this letter reached its destination, Tecumseh, Mr. Bush received a telegram stating that the man had been found, and asking if they should arrest him. The correspondent had not observed the date of the letter, nor suspected that he was reading a novel ; and in a few days the following letter was received :

Tecumseh, *April* 18, 1879.

Mr. R. T. Bush—

Dear Sir: Velina read to me a letter Wednesday evening from you, describing a certain man that was wanted in New York, who had recently left Toledo for this village.

The next morning, after hearing the description, I informed our marshal of the fact, and requested him to keep a lookout for such a man. In the course of half an hour he came to me, saying that he had just seen my man—with sandy whiskers, rather tall—would weigh 170 or 180 pounds—wearing specs, and the front finger of the left hand missing; and was very anxious that he should be immediately arrested, as he was then at the livery-stable, for a saddle-horse to ride away. I told him we had better wait and be sure that he was the one we wanted, and also find out if we could whether you wanted him arrested, should he prove to be the right man. I saw the man, and he answered the description so well, even to the *finger*, that I thought best to telegraph you for instructions. The Marshal, in the mean time, was to keep his eye on him (as he failed to get a horse). Seeing him walk down to dinner with one of our townsmen, the first opportunity he made some inquiries of this townsman, and found that he was not the man—that he was the cousin of this man that took him to dinner, and was brother to a Mrs. Palmer, whom he was visiting—that he lives in South Cleveland, Ohio, and is a lawyer by profession.

That he answered the description, both in size and the loss of the finger, as well as the color of his whiskers, there could be no doubt. Wearing specs we supposed was to hide the defects of that eye you mentioned, and he looked as though his side-whiskers had recently been cut or shaved; but if, as we were told, his home is in Cleveland, and his name is Hick, why of course we were deceived in the matter. And, if his friend has not informed him, he is still ignorant of our suspicions.

Now, as this is my first experience in the detective business, you will pardon the blunder.

Hoping that it has put you to no inconvenience, I remain yours, etc.,

H. Raymond.

The one striking feature of this coincidence is of course the *loss of the forefinger* in the *left* hand.

Both the imagined and the real case possessed this very exceptional peculiarity. This is a subject on which statistics can not be gained ; but it is certain that in the whole continent not a small roomful could be found possessing precisely this deformity at the age specified ; and

it may well be doubted whether in the whole world there is another person thus mutilated and at the same time possessing all the general physical characteristics of the individual described in the letter.

More striking still is the fact that this individual did not reside in the place where the letter was sent (which is not a large place), and was there by chance only the day that the letter reached there.

Those who believe that the mathematical doctrine of chances can solve the complex problems of coincidences will find in this case material for consideration. I may here quote a single sentence from the second of my series of papers on "Experiments with Living Human Beings," in the April number of the "Monthly": "In these and all studies of a like character it is to be recognized that coincidences of the most extraordinary character and astonishing nature are liable to occur at any instant, and that they are as likely to occur on the first trial as on the last of a long series."

A second point of great psychological interest in this case is the attempt made by the person to whom the letter was addressed to overlook certain discrepancies between the imaginary and real individual, and to twist and pervert and reason upon the facts of the case, so as to bring them into harmony with what he was *expecting to see.* While the man corresponded to the description in size, in the color of his whiskers, and especially in the loss of his finger, he did not correspond in the fact that he wore spectacles and had no side-whiskers. The detective reasoned that he wore spectacles to hide the defect in the eye, which defect he did not see; and he assumed, on thought, that the side-whiskers had been recently shaved or cut. Nothing is said of his stooping, or of his being lame in the left leg, or of the color of his hair, or of its length.

The bearings of this whole history on the delusions of clairvoyance mind-reading, animal magnetism, and spiritism are apparent. A successful coincidence of this kind would have made fortune and favor for any clairvoyant, or medium, or mind-reader.

Truly yours, George M. Beard.

New York, *July*, 1879.

THE CLASSICAL CONTROVERSY.

By Professor ALEXANDER BAIN.

ITS PRESENT ASPECT.

IN the present state of the controversy on classical studies, the publication of George Combe's contributions to Education is highly opportune. Combe took the lead in the attack on these studies fifty years ago, and Mr. Jolly, the editor of the volume, gives a connected view of the struggle that followed. The results were, on the whole,

not very great. A small portion of natural science was introduced into the secondary schools; but, as the classical teaching was kept up as before, the pupils were simply subjected to a greater crush of subjects; they could derive very little benefit from science introduced on such terms. The effect on the universities was *nil*. They were true to Dugald Stewart's celebrated deliverance on their conservatism.* The public, however, were not unmoved; during a number of years there was a most material reduction in the numbers attending all the Scotch universities, and the anti-classical agitation was reputed to be the cause.

The reasonings of Combe will still repay perusal. He puts with great felicity and clearness the standing objections to the classical system; while he is exceedingly liberal in his concessions, and moderate in his demands. "I do not denounce the ancient languages and classical literature on their own account, or desire to see them cast into utter oblivion. I admit them to be refined studies, and think that there are individuals who, having a natural turn for them, learn them easily and enjoy them much. They ought, therefore, to be cultivated by all such persons. My objection is solely to the practice of rendering them the main substance of the education bestowed on young men who have no taste or talent for them, and whose pursuits in life will not render them a valuable acquisition."

Before alluding to the more recent utterances in defense of classical teaching, I wish to lay out as distinctly as I can the various alternatives that are apparently now before us as respects the higher education—that is to say, the education begun in the secondary or grammar schools and completed and stamped in the universities:

1. The existing system of requiring proficiency in both classical languages. This requirement is imperative everywhere at present. The universities agree in exacting Latin and Greek as the condition of an Arts Degree, and in very little else. The defenders of classics say with some truth that these languages are the principal basis of uniformity in our degrees; if they were struck out, the public would not know what a degree meant.

How exclusive was the study of Latin and Greek in the schools in England, until lately, is too well known to need any detailed statement. A recent utterance of Mr. Gladstone, however, has felicitously supplied the crowning illustration. At Eton, in his time, the engrossment with classics was such as to keep out religious instruction!

As not many contend that Latin and Greek make an education in themselves, it is proper to call to mind what other things have been found possible to include with them in the scope of the Arts Degree.

* "The academical establishments of some parts of Europe are not without their use to the historian of the human mind. Immovably moored to the same station by the strength of their cables and the weight of their anchors, they enable him to measure the rapidity of the current by which the rest of the world is borne along."

The Scotch universities were always distinguished from the English in the breadth of their requirements; they have comprised for many ages three other subjects—mathematics, natural philosophy, and mental philosophy, including logic and ethics. In exceptional instances, another science is added; in one case, natural history, in another, chemistry. According to the notions of scientific order and completeness in the present day, a full course of the primary sciences would comprise mathematics, natural philosophy, chemistry, physiology or biology, and mental philosophy. The natural history branches are not looked upon as primary sciences; they give no laws, but repeat the laws of the primary sciences while classifying the kingdoms of nature.

In John Stuart Mill's celebrated address at St. Andrews, he stood up for the continuance of the classics in all their integrity, and suddenly became a great authority with numbers of persons who probably had never treated him as an authority before. But his advocacy of the classics was coupled with an equally strenuous advocacy for the extension of the scientific course to the full circle of the primary sciences; that is to say, he urged the addition of chemistry and physiology to the received sciences. Those that have so industriously brandished his authority for retaining classics, are discreetly silent upon this other recommendation. He was too little conversant with the working of universities to be aware that the addition of two sciences to the existing course was impracticable; and he was never asked which alternative he would prefer. I am inclined to believe that he would have sacrificed the classics to scientific completeness; he would have been satisfied with the quantum of these already gained at school. But, while we have no positive assurance on this point, I consider that his opinion should be wholly discounted as not bearing on the actual case.

The founders of the University of London attempted to realize Mill's conception to the full. They retained classics; they added English and a modern language, and completed the course of primary science by including chemistry and physiology. This was a noble experiment, and we can now report on its success. The classical languages, English and French or German, mathematics and natural philosophy, and (after a time) logic and moral philosophy, were all kept at a good standard; thus exceeding the requirements of the Scotch universities at the time by English and a modern language. The amount of attainment in chemistry was very small, and was disposed of in the matriculation examination. Physiology was reserved for the final B. A. examination, and was the least satisfactory of all. Having myself sat at the Examining Board while Dr. Sharpey was Examiner in Physiology, I had occasion to know that he considered it prudent to be content with a mere show of studying the subject. Thus, though the experience of the University of London, as well as

of the Scotch universities, proves that the classics are compatible with a very tolerable scientific education, they will need to be curtailed if every one of the fundamental sciences, as Mill urged, is to be represented at a passable figure.

In the various new proposals for extending the sphere of scientific knowledge, a much smaller amount of classics is to be required, but neither of the two languages is wholly dispensed with. If not taught at college, they must be taken up at school as a preparation for entering on the Arts curriculum in the university. This can hardly be a permanent state of things, but it is likely to be in operation for some time.

2. The remitting of Greek in favor of a modern language is the alternative most prominently before the public at present. It accepts the mixed form of the old curriculum, and replaces one of the dead languages by one of the living. Resisted by the whole might of the classical party, this proposal finds favor with the lay professions as giving one language that will actually be useful to the pupils as a language. It is the very smallest change that would be a real relief. That it will speedily be carried we do not doubt.

Except as a relaxation of the gripe of classicism, this change is not altogether satisfactory. That there must be two languages (besides English) in order to an Arts Degree is far from obvious. Moreover, although it is very desirable that every pupil should have facilities at school or college for commencing modern languages, these do not rank as indispensable and universal culture, like the knowledge of sciences and of literature generally. They would have to be taught along with their respective literatures to correspond to the classics.

Another objection to replacing classics by modern languages is the necessity of importing foreigners as teachers. Now, although there are plenty of Frenchmen and Germans that can teach as well as any Englishmen, it is a painful fact that foreigners do oftener miscarry, both in teaching and discipline, with English pupils, than our own countrymen. Foreign masters are well enough for those that go to them voluntarily with the desire of being taught; it is as teachers in a compulsory curriculum that their inferiority becomes apparent.

The retort is sometimes made to this proposal—Why omit Greek rather than Latin? Should you not retain the greater of the two languages? This may be pronounced as mainly a piece of tactics; for every one must know that the order of teaching Latin and Greek at the schools will never be topsy-turvied to suit the fancy of an individual here and there, even although John Stuart Mill himself was educated in that order. On the scheme of withdrawing all foreign languages from the imperative curriculum, and providing for them as voluntary adjuncts, such freedom of selection would be easy.

3. Another alternative is to remit both Latin and Greek in favor of French and German. Strange to say, this advance upon the previous alternative was actually contained in Mr. Gladstone's ill-fated

Irish University Bill. Had that bill succeeded, the Irish would have been for ten years in the enjoyment of a full option for both the languages.* From a careful perusal of the debates, I could not discover that the opposition ever fastened upon this bold surrender of the classical exclusiveness.

The proposal was facilitated by the existence of professors of French and German in the Queen's colleges. In the English and Scotch colleges endowments are not as yet provided for these languages; although it would be easy enough to make provision for them in Oxford and Cambridge.

In favor of this alternative, it is urged that the classics, if entered on at all, should be entered on thoroughly and entirely. The two languages and literatures form a coherent whole, an homogeneous discipline; and those that do not mean to follow this out should not begin it. Some of the upholders of classics take this view.

4. More thorough-going still is the scheme of complete bifurcation of the classical and the modern sides. In our great schools there has been instituted what is called the modern side, made up of sciences and modern languages, together with Latin. The understanding hitherto has been that the votaries of the ancient and classical side should alone proceed to the universities; the modern side being the introduction to commercial life, and to professions that dispense with a university degree. Here, as far as the schools are concerned, a fair scope is given to modern studies.

As was to be expected, the modern side is now demanding admission to the universities on its own terms; that is, to continue the same line of studies there, and to be crowned with the same distinctions as the classical side. This attempt to render school and college homogeneous throughout, to treat ancient studies and modern studies as of equal value in the eye of the law, will of course be resisted to the utmost. Yet it seems the only solution that can bring about a settlement that will last.

The defenders of the classical system in its extreme exclusiveness are fond of adducing examples of very illustrious men who at college showed an utter incapacity for science in its simplest elements. They say that by classics alone these men are what they are; and, if their way had been stopped by serious scientific requirements, they would have never come before the world at all. The allegation is somewhat strongly put; yet we shall assume it to be correct, on condition of being allowed to draw an inference. If some minds are so constituted for languages, and for classics in particular, may not there be other

* No doubt the classical languages would have been required, to some extent, in matriculating to enter college. This arrangement, however, as regarded the students that chose the modern languages, would have been found too burdensome by our Irish friends, and, on their expressing themselves to that effect, would have been soon dispensed with.

minds equally constituted for science, and equally incapable of taking up two classical languages? Should this be granted, the next question is, Ought these two classes of minds to be treated as equal in rights and privileges? The upholders of the present system say, No. The language-mind is the true aristocrat; the science-mind is an inferior creation. Degrees and privileges are for the man that can score languages, with never so little science; outer darkness is assigned to the man whose *forte* is science alone. But a war of caste in education is an unseemly thing; and, after all the leveling operations that we have passed through, it is not likely that this distinction will be long preserved.

The modern side, as at present constituted, still retains Latin. There is a considerable strength of feeling in favor of that language for all kinds of people; it is thought to be a proper appendage of the lay professions; and there is a widespread opinion in favor of its utility for English. So much is this the case, that the modern-siders are at present quite willing to come under a pledge to keep up Latin, and to pass in it with a view to the university. In fact, the schools find this for the present the most convenient arrangement. It is easier to supply teaching in Latin than in a modern language, or in most other things; and, while Latin continues to be held in respect, it will remain untouched. Yet the quantity of time occupied by it, with so little result, must ultimately force a departure from the present curriculum. The real destination of the modern side is to be modern throughout. It should not be rigorously tied down even to a certain number of modern languages. English and one other language ought to be quite enough; and the choice should be free. On this footing, the modern side ought to have its place in the schools as the coequal of classics; it would be the natural precursor of the modernized alternatives in the universities; those where knowledge subjects predominate.

The proposal to give an inferior degree to a curriculum that excludes Greek should, in my judgment, be simply declined. It is, however, a matter of opinion whether, in point of tactics, the modern party did not do well to accept this as an installment in the mean time. The Oxford offer, as I understand it, is so far liberal, that the new degree is to rank equal in privileges with the old, although inferior in *prestige*. In Scotland, the degree conceded by the classical party to a Greekless education was worthless, and was offered for that very reason.*

Among the adherents of classics, Professor Blackie is distinguished for surrendering their study in the case of those that can not profit by them. He believes that with a free alternative, such as the thorough bifurcation into two sides would give, they would still hold their

* One possible consequence of the new Natural Science Degree may be, that the public will turn to it with favor, while the old one sinks into discredit.

ground, and bear all their present fruits. His classical brethren, however, do not in general share this conviction. They seem to think that if they can no longer compel every university graduate to pass beneath the double yoke of Rome and Greece, these two illustrious nationalities will be in danger of passing out of the popular mind altogether. For my own part, I do not share their fears, nor do I think that, even on the voluntary footing, the study of the two languages will decline with any great rapidity. As I have said, the belief in Latin is wide and deep. Whatever may be urged as to the extraordinary stringency of the intellectual discipline now said to be given by means of Latin and Greek, I am satisfied that the feeling with both teachers and scholars is that the process of acquisition is not toilsome to either party; less so perhaps than anything that would come in their place. Of the hundreds of hours spent over them, a very large number are associated with listless idleness. Carlyle describes Scott's novels as a "beatific lubber-land"; with the exception of the "beatific," we might say nearly the same of classics. To all which must be added the immense endowments of classical teaching; not only of old date but of recent acquisition. It will be a very long time before these endowments can be diverted, even although the study decline steadily in estimation.

The thing that stands to reason is to place the modern and the ancient studies on exactly the same footing; to accord a fair field and no favor. The public will decide for themselves in the long run. If the classical advocates are afraid of this test, they have no faith in the merits of their own case.

The arguments *pro* and *con* on the question have been almost exhausted. Nothing is left except to vary the expression and illustration. Still, so long as the monopoly exists, it will be argued and counter-argued; and, if there are no new reasons, the old will have to be iterated.

Perhaps the most hackneyed of all the answers to the case for the classics is the one that has been most rarely replied to. I mean the fact that the Greeks were not acquainted with any language but their own. I have never known an attempt to parry this thrust. Yet, besides the fact itself, there are strong presumptions in favor of the position that, to know a language well, you should devote your time and strength to it alone, and not to attempt to learn three or four. Of course, the Greeks were in possession of language A 1, and were not likely to be gainers by studying the languages of their contemporaries. So we too are in possession of a very admirable language, although put together in a nondescript fashion; and it is not impossible that, if Plato had his "Dialogues" to compose among us, he would give his whole strength to working up our own resources, and not trouble himself with Greek. The popular dictum—*multum non multa*, doing one thing well—may be plausibly adduced in behalf of parsimony in the study of languages.

The recent agitation in Cambridge, in Oxford, and indeed all over the country, for remitting the study of Greek as an essential of the Arts Degree, has led to a reproduction of the usual defenses of things as they are. The articles in the March number of this "Review," by Professors Blackie and Bonamy Price, may claim to be the *derniers mots*.

Professor Blackie's article is a warning to the teachers of classics, to the effect that they must change their front; that, whereas the value of the classics as a key to thought has diminished, and is diminishing, they must by all means in the first place improve their drill. In fact, unless something can be done to lessen the labor of the acquisition by better teaching, and to secure the much-vaunted intellectual discipline of the languages, the battle will soon be lost. Accordingly, the Professor goes minutely into what he conceives the best methods of teaching. It is not my purpose to follow him in this sufficiently interesting discussion. I simply remark that he is staking the case for the continuance of Latin and Greek in the schools on the possibility of something like an entire revolution in the teaching art. Revolution is not too strong a word for what is proposed. The weak part of the new position is that the value of the languages *as languages* has declined, and has to be made up by the incident of their value as *drill*. This is, to say the least, a paradoxical position for a language-teacher. If it is mere drill that is wanted, a very small corner of one language would suffice. The teacher and the pupil alike are placed between the two stools—interpretation and drill. A new generation of teachers must arise to attain the dexterity requisite for the task.

Professor Blackie's concession is of no small importance in the actual situation. "No one is to receive a full degree without showing a fair proficiency in two foreign languages, one ancient and one modern, with free option." This would satisfy the present demand everywhere, and for some time to come.

The article of Professor Bonamy Price is conceived in even a higher strain than the other. There is so far a method of argumentation in it that the case is laid out under four distinct heads, but there is no decisive separation of reasons; many of the things said under one head might easily be transferred without the sense of dislocation to any other head. The writer indulges in high-flown rhetorical assertions rather than in specific facts and arguments. The first merit of classics is that "they are languages; not particular sciences, nor definite branches of knowledge, but literatures." Under this head we have such glowing sentences as these: "Think of the many elements of thought a boy comes in contact with when he reads Cæsar and Tacitus in succession, Herodotus and Homer, Thucydides and Aristotle! . . . See what is implied in having read Homer intelligently through, or Thucydides, or Demosthenes; what light will have been shed on the essence and laws of human existence, on political society, on the relations of man to man,

on human nature itself!" There are various conceivable ways of counter-arguing these assertions, but the shortest is to call for the facts—the results upon the many thousands that have passed through their ten years of classical drill. Professor Campbell, of St. Andrews, once remarked, with reference to the value of Greek in particular, that the question would have to be ultimately decided by the inner consciousness of those that have undergone the study. To this we are entitled to add, their powers as manifested to the world, of which powers spectators can be the judges. When, with a few brilliant exceptions, we discover nothing at all remarkable in the men that have been subjected to the classical training, we may consider it as almost a waste of time to analyze the grandiloquent assertions of Mr. Bonamy Price. But, if we were to analyze them, we should find that *boys* never read Cæsar and Tacitus through in succession; still less Thucydides, Demosthenes, and Aristotle; that very few *men* read and understand these writers; that the shortest way to come into contact with Aristotle is to avoid his Greek altogether, and take his expositors and translators in the modern languages.

The Professor is not insensible to the reproach that the vaunted classical education has been a failure, as compared with these splendid promises. He says, however, that, though many have failed to become classical scholars in the full sense of the word, "it does not follow that they have gained nothing from their study of Greek and Latin; just the contrary is the truth." The "contrary" must mean that they have gained something, which something is stated to be "the extent to which the faculties of the boy have been developed, the quantity of impalpable but not less real attainments he has achieved, and his general readiness for life, and for action as a man." But it is becoming more and more difficult to induce people to spend a long course of youthful years upon a confessedly *impalpable* result. We might give up a few months to a speculative and doubtful good, but we need palpable consequences to show for our years spent on classics. Next comes the admission that the teaching is often bad. But why should the teaching be so bad, and what is the hope of making it better? Then we are told that science by itself leaves the largest and most important portion of the youth's nature absolutely undeveloped. But, in the first place, it is not proposed to reduce the school and college curriculum to science alone; and, in the next place, who can say what are the "impalpable" results of science?

The second branch of the argument relates to the greatness of the classical writers. Undoubtedly there are some very great writers in the Greek and Roman world, and some that are not great. But the greatness of Herodotus, Thucydides, Demosthenes, Plato, and Aristotle can be exhibited in a modern rendering; while no small portion of the poetical form can be made apparent without toiling at the original tongues. The value of the languages, then, resolves itself, as

has been often said, into a *residuum*. Something also is to be said for the greatness of the writers that have written in modern times. Sir John Herschel remarked long ago that the human intellect can not have degenerated, so long as we are able to quote Newton, Lagrange, and Laplace, against Aristotle and Archimedes. I would not undertake to say that any modern mind has equaled Aristotle in the *range* of his intellectual powers; but, in point of intensity of grasp in any one subject, he has many rivals; so that, to obtain his equal, we have only to take two or three first-rate moderns.

If a number of persons were to go on lauding to the skies the exclusive and transcendent greatness of the classical writers, we should probably be tempted to scrutinize their merits more severely than is usual. Many things could be said against their sufficiency as instructors in matters of thought, and many more against the low and barbarous tone of their *morale;* the inhumanity and brutality of both their principles and their practice. All this might no doubt be very easily overdone, and would certainly be so if undertaken in the style of Professor Price's panegyric.

The Professor's third branch of the argument comes to the real point; namely, what is there in Greek and Latin that there is not in the modern tongues? For one thing, says the Professor, they are dead, which, of course, we allow. Then, being dead, they must be learned by book and by rule; they can not be learned by ear. Here, however, Professor Blackie would dissent, and would say that the great improvement of teaching, on which the salvation of classical study now hangs, is to make it a teaching by the ear. But, says Professor Price, "a Greek or Latin sentence is a nut with a strong shell concealing the kernel—a puzzle, demanding reflection, adaptation of means to end, and labor for its solution, and the educational value resides in the shell and in the puzzle." As this strain of remark is not new, there is nothing new to be said in answer to it. Such puzzling efforts are certainly not the rule in learning Latin and Greek. Moreover, the very same terms would describe what may happen equally often in reading difficult authors in French, German, or Italian. Would not the pupil find puzzles and difficulties in Dante or in Goethe? And are there not many puzzling exercises in deciphering English authors? Besides, what is the great objection to science, but that it is too puzzling for minds that are quite competent for the puzzles of Greek and Latin. Once more, the *teaching* of any language must be very imperfect, if it brought about habitually such situations of difficulty as are here described.

The Professor relapses into a cooler and correcter strain when he remarks that the pupil's mind is necessarily more delayed over the expression of a thought in a foreign language (whether dead or alive matters not), and therefore remembers the meaning better. Here, however, the desiderated reform of teaching might come into play.

Granted that the boy left to himself would go more rapidly through Burke than through Thucydides, might not his pace be arrested by a well-directed cross-examination; with this advantage, that the length of attention might be graduated according to the importance of the subject, and not according to the accidental difficulty of the language?

The Professor boldly grapples with the alleged waste of time in classics, and urges that "the gain may be measured by the time expended," which is very like begging the question.

One advantage adduced under this head deserves notice. The languages being dead, as well as all the societies and interests that they represent, they do not excite the prejudices and the passions of modern life. This, however, may need some qualification. Grote wrote his history of Greece to counterwork the party bias of Mitford. The battles of despotism, oligarchy, and democracy are to this hour fought over the dead bodies of Greece and Rome. If the Professor meant to insinuate that those that have gone through the classical training are less violent as partisans, more dispassionate in political judgments, than the rest of mankind, we can only say that we should not have known this from our actual experience. The discovery of some sweet, oblivious antidote to party feeling seems, as far as we can judge, to be still in the future. If we want studies that will, while they last, thoroughly divert the mind from the prejudices of party, science is even better than ancient history; there are no party cries connected with the Binomial Theorem.

The Professor's last branch of argument, I am obliged with all deference to say, contains no argument at all. It is that, in classical education, a close contact is established between the mind of the boy and the mind of the master. He does not even attempt to show how the effect is peculiar to classical teaching. The whole of this part of the paper is, in fact, addressed, by way of remonstrance, to the writer's own friends, the classical teachers. He reproaches them for their inefficiency, for their not being Arnolds. It is not my business to interfere between him and them in this matter. So much stress does he lay upon the teacher's part in the work, that I almost expected the admission that a good teacher in English, German, natural history, political economy, might even be preferable to a bad teacher of Latin and Greek.

The recent Oxford contest has brought out the eminent oratorical powers of Canon Liddon; and we have some curiosity in noting his contributions to the classical side. I refer to his letter in the "Times." The gist of his advocacy of Greek is contained in the following allegations: First, the present system enables a man to recur with profit and advantage to Greek literature. To this it has been often replied, that by far the greater number are too little familiarized with the

classical languages, and especially Greek, to make the literature easy reading. But further, the recurring to the study of ancient authors, by busy professional men in the present day, is an event of such extreme rarity that it can not be taken into account in any question of public policy. The second remark is, that the half-knowledge of the ordinary graduate is a link between the total blank of the outer world and the thorough knowledge of the accomplished classic. I am not much struck by the force of this argument. I think that the classical scholar might, by expositions, commentaries, and translations, address the outer world equally well, without the intervening mass of imperfect scholars. Lastly, the Canon puts in a claim for his own cloth. The knowledge of Greek paves the way for serious men to enter the ministry in middle life. Argument would be thrown away upon any one that could for a moment entertain this as a sufficient reason for compelling every graduate in arts to study Greek. The observation that I would make upon it has a wider bearing. Middle life is not too late for learning any language that we suddenly discover to be a want; the stimulus of necessity or of strong interest and the wider compass of general knowledge compensate for the diminution of verbal memory.—*Contemporary Review.*

THE VANILLA-PLANT.*

By J. POISSON,

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OF all orchids the vanilla is the one most widely known; its fruit is deservedly esteemed and is an important article of commerce. Its valuable properties long ago brought the vanilla into notice. The fruit appears to have been first introduced into Europe in the beginning of the sixteenth century. The living plant was imported into England, toward the end of the eighteenth century, by Miller; but we can not with certainty determine which one of the few species of vanilla now known was then introduced. Linné, however, gave the name *Epidendrum vanilla* to the plant which had come into his hands, and which is supposed to have been identical with that brought by Miller. Several years later Swartz, on attentively studying the flower of the vanilla, observed notable differences between it and the flower of the genus *Epidendrum*; he was thus led to constitute a new genus, and *Epidendrum vanilla* now became *Vanilla aromatica.* Later Greville brought from America some cuttings of a vanilla differing from *Vanilla aromatica*, especially in the size of the leaves; to this Andrews gave the name *Vanilla planifolia.* This plant was

* Translated from "La Nature" by J. Fitzgerald, A. M.

brought first to England, thence to the Museum at Paris in 1810, and lastly to Belgium ; it is the species whose fruit possesses the strongest perfume.

The vanilla throve in greenhouses, but as it was sensitive to cold, and did not fructify, and its flowers possessed no ornamental interest, its culture was very limited. For a long time the only fruits which came to Europe were from Mexico, or the Gulf of Mexico—the only points where the plant was cultivated on a large scale, and where its fructification appeared to be insured. It remained for later experimenters to add to the interest attaching to this plant, while at the same time, in some degree, augmenting the resources of the colonies.

At this time the impression made by certain recent researches on fecundation in plants was still fresh, and the questions of hybridation and crossing were closely studied.

It has ever since been believed that the fecundation of the vanilla in Mexico and the neighboring countries, where that plant fructifies normally, was brought about by the agency of certain insects which hitherto do not appear ever to have been observed performing this function. The hypothesis is almost equivalent to a certainty, now that we know the habits of the *Orchideæ*, especially as regards reproduction.


VANILLA PLANIFOLIA.

The right of priority in discovering the artificial fecundation of the vanilla has been claimed for many countries. It belongs to England, say those who dwell on the other side of the Channel ; but, if we are to believe the Belgians, the true discoverer was Charles Morren. Nevertheless it appears indisputable that Neumann, head-gardener at the Paris Museum of Natural History, was the first to obtain the results of this fructification in 1830. From a single stock Neumann produced, in that year, over two hundred vanilla fruits of excellent quality.

M. Delteil, pharmacist in the navy, in his interesting study of the vanilla ("Étude sur la Vanille," 1874), gives a list of the works which have been published concerning this plant, and treats of its culture in Réunion Island particularly. He states that in 1839 Perrottet, on his second voyage to Bourbon, made known to some of his friends among the planters the process adopted by Neumann ; for, though the vanilla was cultivated as a curiosity, it did not bear fruit there any more than in Europe. Nothing appears to have come out of this suggestion ; but the case was different with the discovery made about the same time

by a young slave, Edmond Albius, in the service of M. Ferréol Beaumont-Bellier. Albius had noticed how his master, who had considerable acquaintance with natural history, used to produce hybrids by cross-fertilization of the various flowers in his garden. Having made like experiments himself, the young slave observed that, on touching with a spine of palm the flowers of the vanilla, two little yellow bodies contained within changed position, and that fructification resulted from the contact. A new branch of commerce was henceforth created, and vanilla-beans, previously very dear, were quickly much lowered in price.

The vanilla is a climbing plant with pulpy stem, but it can reach the tops of high trees. In our greenhouses it attains proportions sufficiently great to enable us to judge of its appearance. Its stem, which can be easily made to ramify, is from two to three centimetres in diameter. Its leaves are arranged in two rows, or are alternately distichous, as the botanists say. In size they vary from fifteen to twenty centimetres, and they are slightly twisted on their short petiole, so as to appear to be inserted obliquely. This torsion seems to be produced by the need for the leaf of having its upper face always turned toward the light.

Besides the roots at the base of the plant and fixed in the soil, a multitude of adventitious aërial roots start from the stem or the branches, after the plant has reached a certain size. These roots hang free so long as the stem rises vertically, but become fixed in the soil when the stem touches the ground. They start from the level of a leaf alongside of a tendril, with the aid of which the plant climbs trees.

The stem, which in the interval between two leaves takes a direction the reverse of that taken in the next interval—a zigzag—is charged with a thick, vesicating juice, which on being applied to the skin produces a blister.

The flowers appear in clusters at the axils of the leaves, and are numerous; but care is taken to leave only a small number of them on the plant when it is desired to have fine fruit. These flowers last for only one day, and fructification, in order to be successful, should take place in the morning. The instrument used for this operation is a pointed piece of bamboo. A skilled man can fecundate as many as one thousand flowers in a morning. One month after fecundation the fruit has attained its full size, yet it has still to remain on the plant six or seven months more before it reaches perfect maturity.

The flowers of the vanilla have none of that richness of color so common among orchids. They are whitish or yellowish, according to the species to which they belong. Apart from those which are cultivated on account of the perfume of their fruit, the others possess only a purely botanical interest.

A physiological detail that is worthy of mention is the attraction of the stigmas of these flowers for the pollen offered to them. Neumann the younger had frequent occasion to notice this while experi-

menting on the fecundation of the vanilla at the Museum; and in a prize essay by H. Baillon the same fact is confirmed. "When the sky was overcast," he writes, "and the temperature rather low, I had to penetrate into the stigmatic antrum, in order there to place the little pollen apparatus; but, after the sun had made pretty warm the greenhouse in which the plant was suspended, then, provided the contents of the anther were not firmly attached to the top of the pins on which they were borne, they would become detached from it on being brought within a certain distance from the stigma, and, being strongly attracted, would shoot like an arrow into the cavity." This curious observation appears to be without precedent save in this plant; it is certainly of a character to interest the physiologist.

Darwin has observed a strange movement of the pollinia in the flowers of *Catasetum*, which, under the influence of innervation, "were shot forth to the distance of two or three feet"; but here the phenomenon is purely mechanical.

The first travelers who observed the vanilla in the wild state have asserted that it grows in low, moist situations near the seacoast; but in later times it has been found in the forests, and is known to occur in divers parts in Central America.

The number of species of the vanilla-plant is not clearly determined. Of types cultivated in Mexico there are twelve, and of these five are reckoned as distinct species. One of these species, the *Vanilla lec*, embraces six varieties. Delteil gives a list of species cultivated in different countries; it is as follows: In Mexico, *Vanilla sativa*, *V. silvestris*, *V. planifolia*, and *V. pompona*; in Guiana, *V. guianensis*, with yellow flowers and large fruit; at Bahia, *V. palmarum*; in Brazil and Peru, Linné's *V. aromatica*, which possesses less fragrance than the others. In Réunion two sorts are cultivated, both of them apparently varieties of *V. planifolia*.

Under the title of *vanillon* is found in commerce a short, thick vanilla-pod, produced by *V. pompona*, the fruit of which is of far less value than that of the *V. planifolia*.

Now that the cultivation of vanilla is widely extended, the fine quality of beans can be had at from one hundred and eighty to two hundred and fifty francs per kilogramme. But when it is "frosted," i. e., covered with needles of vanillin, it may fetch a higher price. Vanillon is worth about one fourth as much as vanilla.

Vanilla plantations, to be profitable, require great and constant care. The plants are multiplied by cuttings. The cuttings should bear three or four leaves, and may be a metre or over in length. Rainy and hot seasons are chosen by preference for planting. The cuttings must be planted in rows apart, in a soil rich in vegetable molds fertilized with the decaying leaves and branches of plants, especially of the banana. Each cutting should have a prop, and the ground at its root is to be kept moist by a heap of stones around the stem.

The best practice in these plantations is to train the plants on espaliers reaching from one prop to another. Generally the props are themselves plant-cuttings, which bear leaves and so shelter the young plants from the excessive heat of the sun. In case the props are of dead timber, the shrubs which are to afford shade must be planted in the intervals between the vanilla-plants. In addition to these means of shelter the plantation must be surrounded with a hedge of shrubbery for the sake of breaking the force of the winds.

Experience has shown that a vanilla plantation should not be worked for over seven years; but in the mean time a new one is got in readiness, so that there may be no interruption.

The vanilla harvest in Réunion occurs from May to August; in Mexico it takes place in December. The fruits, improperly called pods, are best when they have had good exposure to the sun, are fully mature, but not open, and gathered in a hot, dry season.

The modes of preparation differ according to locality, but in general they may be classed under three heads. The oldest method is that of alternately exposing the fruits to the sun and then keeping them in shade till they are sufficiently dry. This is the practice in Mexico and Guiana, where vanilla of excellent quality is produced. Sometimes they are exposed to the action of artificial heat to hasten the drying. Another mode consists in employing boiling water, in which the fruit is dipped for a while, and then treated with sunlight and shade as above. Finally, the third method consists in employing an oven at the temperature of 50° to 75° Cent.; in this the beans are heated from twenty-four to thirty-six hours. Among the many processes, M. Delteil appears to give the preference to that in use in Réunion, i. e., that which employs boiling water, together with the subsequent treatment. Excellent results are also obtained by spreading the fruit on black cloths and exposing them to the heat of the sun.

Finally, the fruit is sent to the drying-room. Here it remains for about a month, being looked after from time to time. The vanilla is then packed in tin cases to prevent its becoming too dry, which would impair its value.

CHLORAL AND OTHER NARCOTICS.

By Dr. BENJAMIN W. RICHARDSON, F. R. S.

II.

It may be interesting at this point to particularize the character of the influence exercised on life by certain of the agents we have now under consideration. With the action of alcohol and tobacco we are all so familiar it is not necessary to repeat what is known of them as

members of the toxical family of luxury. Let me rather devote a few pages to the consideration of two or three of the less commonly used agents, with the dangers of which the public mind is not so strongly impressed, and with the facts of which it is not so conversant. I will take three of these as the most important at the present time—namely, chloral hydrate, opium, and absinthe.

The serious truth that chloral hydrate after its introduction into medicine was soon made use of as a toxical luxury has already been adverted to. At the meeting of the British Association for the Advancement of Science, held in Edinburgh in the year 1871, I drew earnest attention to this subject. I said—and the words were published in the report of that year (page 147)—"There is another subject of public interest connected with the employment of chloral hydrate. I refer to the increasing habitual use of it as a narcotic. As there are alcoholic intemperants and opium-eaters, so now there are those who, beginning to take chloral hydrate to relieve pain or to procure sleep, get into the fixed habit of taking it several times daily and in full doses. I would state from this public place as earnestly and as forcibly as I can that this growing practice is alike injurious to the mental, the moral, and the purely physical life, and that the confirmed habit of taking chloral hydrate leads to inevitable and confirmed disease. Under it the digestion gets impaired; natural tendency to sleep and natural sleep is impaired; the blood is changed in quality, its plastic properties and its capacity for oxidation being reduced; the secretions are depraved, and, the nervous system losing its regulating, controlling power, the muscles become unsteady, the heart irregular and intermittent, and the mind excited, uncertain, and unstable. To crown the mischief, in not a few cases already the habitual dose has been the last, involuntary or rather unintentional suicide closing the scene. I press these facts on public attention not one moment too soon, and I add to them the further facts that hydrate of chloral is purely and absolutely a medicine, and that, whenever its administration is not guided by medical science and experience, it ceases to be a boon, and becomes a curse to mankind."

This was stated within two years after the substance chloral hydrate came into medical use. If at that time the mind of the public had been as ripe as it is now for the acceptance of the truth, or if I could then have reached the ear of the public more plainly, much evil might have been nipped in the bud. As it was, the warning had little effect, except to expose me to adverse criticism as an alarmist, and the evil has gone on with increasing rapidity and mischief. There is at the present time a considerable community addicted to the habitual use of chloral hydrate on one pretense or another, and a learned medical society has recently framed a series of written questions on the subject, which questions it has felt it expedient to address to members of the profession of medicine generally for their replies.

The persons who become habituated to chloral hydrate are of two or three classes as a rule. Some have originally taken the narcotic to relieve pain, using it in the earliest application of it for a true medicinal and legitimate object, probably under medical direction. Finding that it gave relief and repose, they have continued the use of it, and at last have got so abnormally under its influence that they can not get to sleep if they fail to resort to it. A second class of persons who take to chloral are alcoholic inebriates who have arrived at that stage of alcoholism when sleep is always disturbed, and often nearly impossible. These persons at first wake many times in the night with coldness of the lower limbs, cold sweatings, startings, and restless dreamings. In a little time they become nervous about submitting themselves to sleep, and before long habituate themselves to watchfulness and restlessness, until a confirmed insomnia is the result. Worn out with sleeplessness, and failing to find any relief that is satisfactory or safe in their false friend alcohol, they turn to chloral, and in it find for a season the oblivion which they desire, and which they call rest. It is a kind of rest, and is no doubt better than no rest at all; but it leads to the unhealthy states that we are now conversant with, and it rather promotes than destroys the craving for alcohol. In short, the man who takes to chloral after alcohol enlists two cravings for a single craving, and is double-shotted in the worst sense. A third class of men who become habituated to the use of chloral are men of extremely nervous and excitable temperament, who by nature, and often by the labors in which they are occupied, become bad sleepers. A little thing in the course of their daily routine oppresses them. What to other men is passing annoyance, thrown off with the next step, is to these men a worry and anxiety of hours. They are over-susceptible of what is said of them, and of their work, however good the work may be. They are too elated when praised, and too depressed when not praised, or dispraised. They fail to play character-parts on the stage of this world, and as they lie down to rest they take all their cares and anxieties into bed with them, in the liveliest state of perturbation. Unable in this condition to sleep, and not knowing a more natural remedy, they resort to the use of such an instrument as chloral hydrate. They begin with a moderate dose; increase the dose as occasion seems to demand, and at last, in what they consider a safe and moderate system of employing it, they depend on the narcotic for their falsified repose.

Among these classes of men the use of chloral hydrate is on the increase. The use is essentially a bad business at the best, and while I do not wish in the least to exaggerate the danger springing from it —while, indeed, I am willing to state that I have never been able to trace out a series of fatal organic changes of a structural character from such use—I have certainly seen a great deal of temporary disturbance and enfeeblement from it, without any corresponding advan-

tage that might be set forth as an exchange of some good for some harm. The conclusion I have been forced to arrive at is in brief to this effect: that if chloral hydrate can not be kept for use within its legitimate sphere as a medicine, to be prescribed by the physician according to his judgment, and by him as rarely as is possible, it were better for mankind not to have it at any price.

I expressed an opinion in 1876 that the use of opium, as a toxical agent to which persons habituate themselves, is dying out in this country. I see no reason to modify that view now. I am quite sure that among the better classes the practice of taking opium is less common than it was formerly, and I believe that chloral hydrate has more than usurped its place. The idea, gathered from one or two local practices, which, like a fashion, come and go, that opium-eating is on the increase among the poorer members of society, is, I believe, equally fallacious. I can discover no warranty for any such a general and sweeping assumption. As to the assertion that those who are by their pledge removed from the use of alcoholic drinks, who are professed abstainers, are more addicted to opium-eating than alcoholic drinkers, the idea is too absurd, and can only have been suggested for the sake of the mischief that might follow a promulgation of the notion that, because one devil is cast out of a man, another must enter that is worse than the first. The facts really tell all the other way. The facts in the main are that those men and women who from principle abstain from one form of intoxicant most resolutely abjure all forms; and that those who indulge in one form are more apt than the rest to indulge in more than one. In the course of my career I have met with some persons of English society who have indulged in the use of opium; but I have never met one such who did not also take wine or some other kind of alcoholic drink. Putting the matter in another way, I can solemnly say that in the whole of my intercourse with the abstaining community—and few men indeed have been thrown more into contact with that community—I have never met with an instance that afforded so much as a suspicion of the practice of indulging in narcotism from opium, or any other similar drug. I have never yet met with an abstainer who was even habituated to the use of chloral hydrate. A few abstainers smoke tobacco, but, as the habit seriously taxes their physical health, most of them in due time forego even the luxury of the weed so soon as they discover its injuriousness.

The actual opium-eaters of modern society, who form a natural part of the nation as English people, are extremely limited in number, so limited that the mortality returns give no clew to them as a class suffering from the indulgence. I know not either of any physician or pathologist who has made a study of the organic changes induced in the bodies of natives of these islands who have died from the effects of opium. Still there are a few who indulge; and I fear that among the children of the poor, the infant children, the use of narcotics con-

taining opium is an abused, much-abused system. The adults who indulge are, according to my experience, of three classes: There are some who in the course of disease attended with long-continued acute pain, like neuralgia pain, have found relief from opium, and who having so become habituated to its use keep up the habit sometimes because they feel that they can not sleep without the drug, and sometimes because they have learned to experience a real luxury from its use. There is a limited section that has learned the practice of swallowing or of smoking opium from some Eastern association, and is professed in the practice in a certain moderate degree. Lastly, there are a few doubtless among the poorest of the community, who in some particular localities learn to partake of the narcotic, often not being aware of its true nature, and obtaining it under some fanciful name which has no direct reference to the narcotic itself.

To the few who in these classes may be called opium-eaters might be added a small number of alcoholic inebriates who partake of an opiate occasionally with their spirituous potations.

To whichever class they who habitually resort to opium may belong, they pay dearly for their temporary pleasure. They are a miserable set in mind as in body. They are preserved, as it were, in misery; they do not suffer acute diseases from their enemy, as the alcoholics do, by which their lives are abruptly cut short, but they continue depressed in mind, feeble and emaciated in body, and incapable of any long-continued effort. De Quincey, in language somewhat figurative and poetical, has described the class with a force, and on the whole a correctness, which may be accepted as a faithful record.

I can not report even so favorably on the use of absinthe as I have reported above on the use of opium. There can not, I fear, be a doubt that in large and closely packed towns and cities the consumption of absinthe is on the increase. In London it is decidedly on the increase. It is not possible to find a street in some parts of the metropolis in which the word "absinthe" does not meet the eye in the windows of houses devoted to the sale of other intoxicating and lethal drinks. Much of this advertisement of an unusually dangerous poison is made from ignorance of its nature as much as from cupidity. The suggestion for offering absinthe is that it is an agreeable bitter, that it gives an appetite, and that it gives tone to weak digestions. It is proffered much in the same manner as gin and bitters, and as in some private houses sherry and bitters are proffered. If you ask a seller of absinthe what he vends it for, he tells you, "As a tonic to help digestion."

There is no more terrible mistake than this statement. Absinthe as it is made in France, whence it is imported, is a mixture of essence of wormwood (*absinthium*), sweet-flag, anise-seed, angelica-root, and alcohol. It is colored green with the leaves or the juice of smallage,

spinach, or nettles. It is commonly adulterated. M. Derheims found it adulterated with sulphate of copper, blue vitriol, which substance is added in order to give the required greenish color or tint, as well as to afford a slight causticity, which to depraved tastes is considered the right thing to taste and swallow. M. Stanislas Martin stated that he found chloride of antimony, commonly called butter of antimony, as another adulteration used also to give the color. Chevalier doubts this latter adulteration, but the adulteration with the sulphate of copper is not disputed. The proportion of essence of wormwood to the alcohol is five drachms of the essence to one hundred quarts of alcohol. The action of absinthe on those who become habituated to its use is most deleterious. The bitterness increases the craving or desire, and the confirmed *habitué* is soon unable to take food until he is duly primed for it by the deadly provocative. On the nervous system the influence of the absinthium essence is different from the action of the alcohol. The absinthium acts rather after the manner of nicotine; but it is slower in taking effect than the alcohol which accompanies it into the organism. There is therefore felt by the drinker first the exciting relaxing influence of the alcohol, and afterward the constringing suppressing influence of the secondary and more slowly acting poison. The sufferer, for he must be so called, is left cold, tremulous, unsteady of movement, and nauseated. If his dose be large, these phenomena are exaggerated, and the voluntary muscles, bereft of the control of the will, are thrown into epileptiform convulsions, attended with unconsciousness and with an oblivion to all surrounding objects which I have known to last for six or seven hours. In the worst examples of poisoning from absinthe the person becomes a confirmed epileptic.

In addition to these general indications of evil there are certain local indications not less severe, not less dangerous. The effect which the absinthe exerts in a direct way on the stomach would alone be sufficiently pernicious. It controls for mischief the natural power of the stomach to secrete healthy digestive fluid. It interferes with the solvent power of that fluid itself, so that taken in what is considered to be a moderate quantity, one or two wineglassfuls in the course of the day, it soon establishes in the victim subjected to it a permanent dyspepsia. The appetite is so perverted that all desire for food is quenched until the desire is feebly whipped up by another draught of the destroyer. In a word, a more consummate devil of destruction could not be concocted by the finest skill of science devoted to the worst of purposes than is concocted in this destructive agent, absinthe. It is doubly lethal, and ought to be put down peremptorily in all places where it is sold. Our magistrates have full power to deal with this poison, if they had the discretion and the courage to use their power. They could prohibit the license to all who sell the poison. Beyond this, there is another power that ought to come into play.

Absinthe should be under the control of the Sale of Poisons Act, and no person ought to be able to get it in any form at all without signing a book and going through all the necessary formality for the purchase of a poison. To move the country to a due regard for its own interests as well as for the interests of the ignorant and deluded toxicomaniacs who indulge in absinthe, is the duty of all honest and truthful men.

It is my business in the remaining part of this communication to deal with a question which springs out of the practice of using lethal agents, and with which the minds of the thinking community are sorely exercised. The question I refer to is—Whether the use of these agents springs from a natural desire on the part of man, and of animals lower than man, for such agents; or whether it springs from a perversion or unnatural provocation acquired and transmitted in hereditary line, a toxico-mania, in plain and decisive language.

In respect to the idea that these agents are demanded by living animals as necessities of their transitory existence and residence on this earth, it must be obvious that the argument, as so stated, is based on the desire which has been impressed on the mind of the reasoners by the agents themselves. It is quite certain that men, and all the lower animals, can live without the supposed aid afforded by these substances, and that when they are not known life goes on smoothly and happily enough in their absence. They therefore are only pleaded for when they have made themselves felt, which looks strangely like an artificial pleading for an artificial as apart from a natural thing. Children do not plead for them; men who have been educated without them do not plead for them; animals do not beg for them; none ask for them until by education they have learned to use them. At first all rebel at them, and only after a fiery trial, during which they get over repugnance, acquire a liking to them, after which the liking may run into desire, and desire into infatuation.

Again, if these agents were natural for the wants of man and animal, they would not reasonably be expected to be left so far away, as they are left, from the immediate reach and possession of man and animal. To secure them for man and animal they have to be produced; to produce them, requires human ingenuity and skill, knowledge, science, and in some cases, as in the case of alcohol and alcoholic beverages, a very considerable degree of skill and an enormous amount of skilled labor. It is true that two of these substances, absinthium and opium, lie nearer at hand than the others, might be gathered and utilized by men in their savage state, and might be plucked and eaten even by beasts of the field. But the fact really seems to be that these very simples have not come into the possession of man for the service of the human family until by art the educated of the human race have learned the mode of use; while the lower animals, instead of instinctively finding them out and claiming the advantages which come from

them, have instinctively avoided them with an instigation of common sense that might happily have been imitated by their superiors in wisdom and intelligence.

Moreover, it has generally turned out that all which is required by man as a necessity for his existence has been in the most signal manner provided for him. He is a water-engine, so water is ready at his command; he is a muscular-engine, so muscle-forming substance is at his instant command; he is a passive skeleton, so the materials for the skeleton are at his ready command; he is a receptive organism through his nervous organization, so everything that is wanted for that system is ready prepared. He requires light to bring him into visible communion with the external world, and ere he existed the sun was ready to give him light and to quicken him with heat and motion. He requires sound, and there is the prepared atmosphere ready to vibrate in obedience to his voice. These were all pre-prepared for the man and his life. Is it possible that something more was wanting that he, in course of ages, had to discover? Suppose, like the lower animals, he had failed to discover, what then had been his fate?

To my mind—and I wish to be as open to conviction on this point as any one can be—I fail to discern a single opening for the use of these lethal agents in the service of mankind save in the most exceptional conditions of disease, and then only under skilled and thoughtful supervision, from hands that know the danger of infusing a false movement and life into so exquisite an organism as a living, breathing, pulsating, impressionable human form.

In the argument that these lethal agents are necessities, instinctively selected and chosen to meet human wants, there is no logical sequence. It is all confusion, assumption, apology for human weakness, exaltation of human weakness, sanction of temporary and doubtful pleasure, compromise with evil, and acceptance of penalties the direst, for advantages the poorest and least satisfactory. But when we turn to the other argument—when we reason that these lethal agents induce a physical and mental aberration which they afterward maintain—when we but whisper the word toxico-mania, as the exposition of their influence, all is clear enough. We leave the purely natural world of life to enter the aberrant world, and all there is as it would be to eyes from which the scales of superstition have fallen. These agents play no part in natural function or construction, but add a part which is obviously an aberration. If into a steady-going locomotive-engine the engineer infused some gallons of brandy, he would do something that would be conspicuous enough, but he would not thereby play a natural part in the working of that engine. He would only add a part which would be an aberration. There might be more rapid pulsation and motion for a brief period truly, but the pressure would be unequal, the working-gear unsteady, and by much repetition of the same act there might be accident, apoplexy, stroke, even in an engine, and there cer-

tainly would be a wearing-out which would lead to a limited future. So with the body under these lethal spells; we may add a part, or we may take a part away, but we can not by them maintain the uniform and natural law of life.

These agents create a desire, a craving for themselves, a new automatic expression, a new sense of necessity which did not preëxist, and which never exists until it is acquired. This seems to me the most perfect evidence of aberration. Whoever craves for anything is aberrant, and much craving for one thing is the most certain sign of a mad mind. We all admit this truth when the craving becomes insatiable; but between the smallest persistent craving and the most lamentable insatiate there is nothing more than degree; the fact is the same, and the movement along the line from the moderate toward the insatiate is commonly too easy and continuous. Craving for purely natural things in the midst of them is an unknown phenomenon in healthy men. Craving for unnatural things in the midst of them is well known; but is that healthy? The sane man who wants water asks for it; the sane animal that wants water seeks for it; the aberrant man clutches wine; the aberrant animal, rendered aberrant by the acquired craving, grows furious. No man drinks wine as he drinks water; there is a furor in the drinking of wine which marks a phenomenal disturbance, and which is distinct from the simple act of drinking from necessity, in the act as well as in the object.

The establishment of the craving or desire for these lethal agents in one living body is the frequent origin of the same desire in bodies that are to be. The craving is thus sometimes begotten of a craving, like other hereditary taints which lead to physical and mental errors and diseases, a specific indication of aberration from the natural health into disease, depending on hereditary constitutional tendency, and singularly indicative of original departure from the natural life. A still more striking illustration of the position I am now supporting is afforded in another action of these agents. The tendency of their action is, as a rule, toward premature physical death: the tendency is also toward premature mental death. A sudden excess of indulgence by any one of them, save perhaps arsenic, is all but certain to lead to some form of acute mental derangement or stupor, more or less decisive and prolonged. A gradual excessive indulgence is almost as certain to lead to a confirmed condition of aberration more or less determinate. If we watch carefully the career of a man who is passing through the course of an alcoholic intoxication, and if, after analyzing each phase of that progress, we pass into a lunatic asylum and look at the various phases of insanity exhibited in the persons of the different inmates who are there confined, there is no difficulty in finding represented, through certain of those unfortunates, all the shades of mental aberration which have previously been exhibited by the single person in the course of his rapid career from sanity into insanity and into

helpless paralysis. The wonder suggested, by such analysis of natural phenomena, is not that forty per cent. of the insanity of the country should be directly or indirectly produced by one lethal agent alone, but that so low a figure should indicate all the truth.

When, then, we fairly consider the two questions now before us—whether the lethal agents are called for because they are demanded by a law of natural necessity, a law which stands above man, and is dominant over his nature because independent of him; or whether there is no such law whatever, but an error of man himself, by which he institutes for himself a taste for lethal derangement, and, making for himself and his heirs a new constitution, begins thereupon to justify what he has done on the basis of the constitution he has established—when, I repeat, we consider these two questions, we can, I think, come but to one conclusion. We must, if prejudice be not too strong, lean to the view that man makes the constitution he defends, and that it is the lethal agent, speaking as it were through him, on which a defense of all these agents, common or uncommon, rests for its support.

There is one final argument which many set up who are not content with either of the two views above described. This argument is that, in the natural state of man and beast, the things which "wreathe themselves with ease in Lethe's walk" are not in any sense necessary things. On the contrary, the things are decidedly injurious, and should not be used. At the same time, it is also admitted that the indulgence in lethal agents is, in truth, a mania which begets a mania, and which inflicts all kinds of follies, crimes, and miseries on the race. But, continues the argument, the mania being admitted as such, is rendered justifiable by the circumstance that they who make it and propagate it do not start from the natural condition. They find in the world so much care, so much sorrow, so much misery, and their own path is bestrewed with so many anxieties and difficulties, that they are, in fact, diseased. All society is diseased. Therefore, to meet this vast amount and volume of disease, remedies of a palliative kind are required. Exceptional conditions call for exceptional measures. A man who can not sleep, owing to the cares and anxieties of his life, must take chloral hydrate or opium to obtain sleep. A man who can not finish a certain amount of work against time, by his own natural powers, must whip himself up to the work by means of wine; must force his heart and brain on against time at all risks and sacrifices. A man who has forced himself on against time, and has thereby obtained a momentum which he can not arrest by ordinary means, must calm himself down by tobacco, must literally put the reins on his heart, and pull the heart up sharply and decisively. These remedies, at all risks of learning to crave for them, at all risk of falling the victim to toxico-mania, must be accepted, that the work of the world may go on at full pace.

The argument is specious. If it be a sound argument, it must be

the fact that they who, for the sake of the world, are throwing their lives behind them as fast as they can, are doing more work and better work than they who, keeping their lives in their hands, are content to labor without resort to any perilous adventitious assistance. Is it so? Is the man who never touches a lethal weapon—alcohol, opium, tobacco, chloral, hasheesh, absinthe, or arsenic—a worse man, a weaker man, a less industrious man, a less-to-be-trusted man, than he who indulges in those choice weapons ever so moderately, or ever so freely? If he is, then my position is confessedly undermined, and toxico-mania is a blessing, with all its curses.—*Contemporary Review.*

SPONTANEOUS AND IMITATIVE CRIME.

By E. VALE BLAKE.

IT is not to be expected that law-makers or the administrators of legal justice should discriminate between spontaneous and imitative crime; but to the patient thinker, the medical scientist, and the practical philanthropist it is evident that the grades and distinctions of actual criminality are almost as various as the individual criminals. Even the word crime is very indefinite, and by no means always indicates the true character of an act usually so designated. Acts innocent in themselves—such, for instance, as buying goods in a foreign market and bringing them for use to this—may be made a legal crime by statute law, while other acts which are monstrous violations of natural human rights may be and are ignored by the code, and are perpetrated with impunity in the highest grades of civilized society. So, also, really criminal acts may be committed, and yet crime be absent, for the essence of crime in the individual (excluding for the present the rights of society) lies in the intention, and this element, through physiological and moral reasons, may be void. Indeed, could we apply a mental and moral vivisection to the cases of individual criminals, we should probably find unexpected variations as to the causes and influences tending to its development; but practically we may summarize the whole mass of law-breakers under either one or the other division which the title of our article indicates: and, if by some subtile alchemy we could perceive the main dividing line separating the criminal classes into those who act from the spontaneous impulses of their nature and those who are led into crime mainly by the influence of their peculiar νόμος, or social environment, we should be in a fair way to learn how crime might be diminished, and the so-called "dangerous classes" prevented from spreading its infection.

By spontaneous criminals we mean those who act from well-defined motives, from avarice, revenge, the gratification of pride, vanity, or the

grosser passions—also those who from congenital defects of organization have strong natural tendencies toward the commission of crime—sporadic criminals against whom it is scarcely possible for society to protect itself, unless, like the ancient Spartans, it is prepared to undertake the entire education of the future citizen, morally, intellectually, and physically, including the ante-natal period. Some recent investigations and social experiments have proved that, numerous as these are, they are a small minority as compared with those of the imitative and therefore curable class.

Alibert, the ingenious author of the "Système Sensible," regarded the *instinct of imitation* as the primordial law of nature, which has ruled, taught, and bound together the successive generations of the human race in a more potent manner than any other single faculty: and our every-day observation and experience tend to confirm the sagacity of this remark; and in the matter of crime it is certainly one of the permanent sources of its development and increase. There is one patent fact recognized by the average mind of the community, that the record and publication of any extraordinary crime is very certain to be followed by one or more examples of the same description. This certainly hints at some psychical influence worthy of examination, though it is generally dismissed with an expression as to its being a "singular fatality"—such as appears to follow certain kinds of accidents by flood or field, by land or sea.

The *forms and phases of imitation* are extremely varied—being sometimes the outcome of the conscious will, but not infrequently it is the result of an automatic sympathy with which the will has nothing to do. In many cases imitation is simply the active form of nervous sympathy and approaches the condition of mania. This instinct or faculty, like all other human attributes, may be well or ill applied, but the essential fact remains ever true that the instinct itself is irrepressible, and will exercise itself in some form: and, often as it is misused, the world could not afford to dispense with it. The race would make small progress if every man had to begin *de novo*, instead of imitating the previous acquirements of his ancestors. We may even admit, with the French philosopher, that without the perpetual use of the imitative faculty there could be no distinctive nationalities; for, is it not by successive generations imitating their parents that national customs, usages, and languages are formed, and communities consolidated so as to afford each other mutual support? And the important fact should not be lost sight of that the faculty of imitation is one of the earliest developed, and has acquired strength and vigor long before the reflective faculties or the judgment is prepared to sit in council upon these immature tendencies; particularly should this be remembered in connection with all efforts in behalf of the weaker members of our human brotherhood—whether the young, as such, or the incipient criminal, in which this faculty often plays so considerable a part;

adding complications to the history and the frequent mysteries of crime. What is that which we call "*esprit de corps*," the "spirit of the age," and other similar intangible somethings, which we know exist, but which it is difficult to embody in anything more material than a phrase? What these expressions indicate simply is, that certain numbers, greater or smaller, are prepared to imitate each other, whether it be in a crusade to the Holy Sepulchre, a Flagellant procession, or a modern strike of Crispins or engineers.

Imitative crimes are often motiveless in the ordinary meaning of the word, while numerically they really exceed all others; and it is somewhat curious that this feature of criminality has been so slightly noticed by statisticians and others concerned in the eradication of crime. Other causes of crime are certainly more obvious, for they lie upon the surface—ignorance, poverty, intemperance, the desire to live beyond one's legitimate means, unrestrained passions of all kinds: these are of course the leaders and pioneers of the great criminal army; but the rank and file are mainly made up of imitators, who do as they see others do with whom they associate. Take as an illustration the "great strike" of the railway employees some two years since, in the States of Pennsylvania and New York and elsewhere, and separate if you can the number of individuals who acted from conviction and deliberate intention—with what we might call a reason—however misguided, and the number who burned, hacked, and hewed simply because others were devastating and destroying. Could all of the mere imitators have been eliminated from those mobs it would scarcely have required military force to have dealt with the remainder, the few active, intelligent leaders of that violent mode of argument.

It will probably be admitted, in most cases of mob violence, that the mass of intimidators are ignorant, unreasoning followers, who, if they think at all, only reflect to the extent of supposing that the presence of numbers will suffice to conceal their individual share of the crime; but possibly some of our readers may not be so ready to admit that the faculty of imitation works quite as potentially in secret, where to aid it come various suggestive faculties, such as emulation, vanity, imagination, contrivance, secretiveness, hope, despair, and various other emotions. The concealed imitator broods unobserved of his fellows, and acts only when he deems himself safe from interruption.

The history of the world is full of crimes and follies committed under the influence of the imitative instinct. In many cases so devoid of thought are the actors in these scenes as scarcely to bring them under the judgment of responsible human beings. It is in fact no easy task to draw with any degree of accuracy the dividing line between folly and crime, especially when the exalted sentiments of patriotism or the fanaticism induced by the misapplication of religious dogma, or fervent appeals to the emotions, are the basis of certain wild proceedings; engaged in by assemblies of the intensely nervous, led by knaves

or the self-deceived victims of their own illusions. Under what category, for instance, should we place the "biting nuns" who appeared in rapid succession in the convents of Germany, Holland, and Rome? This extended mania arose simply from the spontaneous act of one nun attempting to bite a companion—immediately the whole sisterhood fell to biting each other. The news of this extraordinary occurrence was told from place to place, and "biting nuns" became a terror and a nuisance, over large portions of Europe in the fifteenth century; this mania proved irrepressible until exhaustion and reaction set in, terminating its abnormal absurdities.* In France another foolish epidemic of imitation seized upon many of the conventual houses. A nun one day commenced to imitate the mewing of a cat, and incontinently the other Sisters present fell to mewing. Finally the nuns took to mewing in concert for hours at a time; persuasions and commands for once failed to produce obedience. The mewing nuisance continued unabated, until the whole sisterhood were threatened with the entrance of the military, who it was announced were "coming to whip them with iron rods." The fear of these rough chastisers finally effected a cure.

That such scenes should happen, through nervous sympathy, in secluded assemblages of women, is not so very remarkable, at least is not inexplicable on nervo-physiological grounds; but we find even more disastrous examples among men, even those habitually living in the open air, within the ordinary conditions of life, and accustomed to muscular labor, which is a great tamer of the nerves. One of the most extraordinary scenes ever witnessed in wonder-producing Europe was enacted in Aix-la-Chapelle and other cities, commencing in 1374, when an assemblage of persons appeared in the famous Westphalian city, who had "danced their way through Germany." At one period the column was estimated to consist of 30,000 persons. In Metz alone there were 1,100. These people, men, women, and children, animated by an imitative delusion, apparently without any power of self-control, danced and leaped for hours at a time in the public streets of cities and on the highways of the countries through which they passed. Nothing could stop them, and they only ceased when exhausted muscles could do no more, when they fell to the ground, suffering more or less from this violent and spasmodic action. The first bands which appeared were, it is charitable to suppose, composed of sporadic cases of victims of that terrible nervous disease known in our day as St. Vitus's dance, and other nervous afflictions such as epilepsy, whom accident or sympathy had brought into companionship; but as these, at first few in number, proceeded from place to place, they were joined by others who, up to that time, had betrayed no symptoms of ill health or insanity, but who, attracted by the unusual sight, first *followed and wondered, ending by joining the leaping, dancing crowd*, to the amazement of their friends with robuster nerves, who were able to resist the fascination.

* See Zimmermann "On Solitude," vol. ii., for this and account of "mewing nuns."

These peripatetic assemblages moved in a direct line, and could only be stopped by putting obstructions in their way which were too high to be leaped over. From the violence of their exercise some were permanently injured, though many of them had been strong, athletic mechanics and peasants who had left their workshops and fields; while others continued with them for a short period, and then returned to their usual occupations as if nothing special had happened.

In Italy the dancing mania originated in the spasmodic action of a person who believed himself to have been bitten by a *tarantula*, or venomous spider, and his singular dancing movements being seen and extensively reported, every one who found a little speck or injury upon his body began to imagine that he also had been bitten, and consequently to imitate the actions of the original nervous victim. The army of imitators daily increased, and their apparent malady could only be relieved by music, mostly of a lively kind, which aided them to "dance out the attack"; it was for this purpose that the gay music now known as the *Tarentella* was invented, which has finally become a form of national music in Italy. Toward the waning of this mania, many of the poorer class, especially women, would seize upon the opportunity, whenever this music was heard in the streets, of joining the throng of dancers, so that the season for the appearance of the players—early summer—came at last to be called the "Women's Little Carnival."

A still more curious and offensive form of imitative mania, combined with imposture, was that of the various armies of Flagellants who marched through Germany and other parts of Europe; in this case the singular movement was led by designing persons who desired to undermine the power of the priesthood and to turn their dethronement to their own profit; but the mass of followers had no idea of the aim and object of the movement, viewing it, so far as they had any reason, as an act of acceptable penance: the great majority, as usual, uniting with the body simply through the irrepressible instinct of imitation—to do as others were doing, just as we have seen young people following one another up to the altar to be prayed for during a so-called revival of religion—not one in a score of whom would have ventured to be the first. Even the recent mania of suddenly "lifting" church debts by the high-pressure method of inciting the instinct of imitation and emulation in the mode of subscribing, was very sagaciously based upon this well-recognized principle that the foolish many will always try to do what the leaders of society initiate, often with as little reason as a herd of quadrupeds. The "walking" mania is a still later example of the irresistible fascination of doing what others are doing.

But it is not always in masses that the powerful instinct of imitation shows itself. In nothing is it more common than in the form which suicides adopt—and suicide is naturally enacted *à la solitaire.*

At one period in France the fashionable mode of exit was by the inhalation of charcoal-fumes, at another by a leap into the Seine. In London a certain monument had to be closed to visitors to prevent would-be suicides from following the example of an original who had thrown himself from the top. A public promenade in Berne, above the Aar, is also much affected by suicides in that vicinity. In this matter of suicide a remarkable example is given of the power influencing to direct imitation, by Dr. Carpenter in his "Mental Physiology." This case was quite devoid of excitement or of any emotional character. He says that Dr. Oppenheim, of Hamburg, having received for dissection the body of a man who had committed suicide by cutting his throat, but who had performed the deed in such an inartistic manner that his death did not take place until after an interval of great suffering, jokingly remarked to his attendant: "If you have any fancy to cut your throat, don't do it in such a bungling way as this—a little more to the left here, and you will cut the carotid artery." The individual to whom this dangerous advice was addressed was a sober, steady man, with a family and a comfortable subsistence; he had never manifested the slightest tendency to suicide, and had no motive to commit it; yet, strange to say, the sight of the corpse and the observation made by Dr. Oppenheim, suggested to his mind the desire to imitate the deed, and this took such firm hold of him that he carried it into execution, fortunately, however, without duly profiting by the anatomical instruction he had received, for he failed to cut the carotid artery, and recovered. Here, plainly, the *ideational form of imitation* took possession of the man's mind, and forced him to the act. Subsequently to the remark of the Doctor, he had evidently brooded over the matter till the desire to imitate the suicide became irresistible. Had Dr. Oppenheim anticipated any result from a casual remark, he would probably have said: "Don't think about this body after you leave here; occupy your mind with some other subject—if possible, a pleasant one."

A curious case of suicidal mania occurred a few years since, under the writer's own observation, in Essex County, New Jersey, where a young man of feeble intellect, but exceedingly susceptible to praise and sympathetic emotions, committed suicide, with the evident intent of drawing out the pity and sympathy of his friends. He had attended one or more funerals where eulogies of the deceased, flowers, and other tokens of kind feeling abounded, and he desired to be in the place of the corpse, and to know that such a scene would be imitated in his case—his limited reasoning powers not suggesting that he would then be insensible to the friendly manifestations. The imitative instinct was too strong for the reflective faculties and determined the fatal act.

Another case in point is that of an eminent physician who, in relating his own experience while suffering under an attack of fever attended with delirium, states that, being obliged to call in a colleague

for treatment, he heard his friend caution the nurse to "keep the windows closed, as one of his fever-patients had attempted to jump out." No sooner had the sick man heard this than he set his mind to circumvent his attendant and jump out of the window, though, until he had heard the cautioning remarks, such a desire had not occurred to him. His intention was happily frustrated, and, as soon as he recovered, he resumed his hospital practice. Strangely forgetting the presence of the patients, he related to some of the other physicians present his experience, and was only made aware of his imprudence when told that, after he had left, several of the sick had risen from their beds and attempted to jump out of the windows.

Without endorsing the apothegm of the able author of the "Intellectual Development of Europe," that "the equilibrium and movements of humanity are *altogether physiological phenomena*, and that the succession of events are the inevitable results of a law depending on, or the consequences of physical conditions," we are persuaded that a large proportion of crime is to be attributed to the responsive nature of the physical organization. Among unsophisticated persons, untrammeled by etiquette, there are many who can not hear a march played without attempting to keep step with the music, or a waltz without an instinctive desire to dance. There is, indeed, a certain amount of rhythmical response in most of us to the time measurements of harmony—particularly when lively airs are played; but as some more than others are easily affected by moral and physical harmonies, may there not be other souls, or vitalized bodies, which spontaneously respond to the moral and physical discords—people who may be said to be out of tune with the organized harmonies of society, and whose natural impulse is to put these into modes of activity?

Plato recognized these differences in the impulses of persons differently constituted and educated; he says in vol. iv. of his "Laws," "I do not expect or imagine that any well-brought-up citizen will ever take the infection [of crime], but their servants or those of strangers may." Speaking of those who might be tempted to crime, he perceives very clearly the power of association over the imitative instinct of human beings, especially of those who dwell together, and he thus advises: "When any such ill thought [as that of committing a crime] comes into your mind, go at once to the society of those who are called good among you. Fly from the wicked; fly, and turn not back, and, if thy disorder is lightened by these remedies, well and good; but if not, then acknowledge death to be nobler than life, and depart hence."

Without going so far as the noble Greek, and recommending suicide to those cursed with evil instincts, we concede that the first part of his advice is as sound to-day as it was two thousand years ago. The power of a dominant idea is almost irresistible in some natures; and, therefore, it should be the aim of every philanthropist, whose efforts are directed to the reduction of crime, to seek the introduction of

good and noble thoughts particularly among the young of the tempted classes.; for all normal or abnormal action is derived from the thoughts, and as the thoughts are, so will the life be. In those particular localities where crime seeks to shelter and hide itself among numbers, the suggestions to wrong-doing are ever present, and the young, who as yet have the criminal instinct only latent, but who still must be regarded from the circumstances as incipient criminals, are the objects which offer the best promises of success in any effort for the reduction of crime. There is also this promising feature in reformatory efforts, *that the moral emotions, once thoroughly awakened, do not satiate and deaden by exercise*, like many pleasurable vices; they are not in their nature exhaustive, but strengthen by habit and prove more satisfying by use and perseverance, till they become almost automatic, when the individual may be considered practically safe.

It is well understood by natural scientists that in the noblest forms of animal life—such, for instance, as the thoroughbred horse—the likeness of parent and offspring is much more strongly marked than in lower forms of life. If we carry our investigations low enough—down to the border-land between the animal and vegetable kingdoms, such as some forms of marine life, hydro-zoöphytes, salpa, and medusæ—we discover a *curious law of unlikeness* or alternation of forms, in which the immediate offspring are totally unlike their progenitors, but possess a resemblance to their ancestors one degree further removed, and this alternation goes on with an invariable tendency in the third generation to revert to the form of the first instead of assuming that of the second. This polymorphic tendency of low types of life is also illustrated in the vegetable world, for, while the higher classes retain, under all conditions, their normal form, whether planted in favorable or unfavorable soil (the oak is still an oak, the rose a rose), the germs of the simpler fungi develop surprising variations of form if placed on different kinds of decomposing matter; so far have these changes proceeded as to cause investigators to mistake them, not only for different species, but for different genera. It thus appears to be a law of nature that the *nobler the production the more type-giving power it possesses*, while the weaker and simpler are dominated by circumstances, and, if weak and low enough, do not necessarily impress their own image on their successors. May not this law apply to some extent to the human race? The nobler specimens of humanity will, we know, maintain their manhood and moral integrity under the most adverse circumstances, but, if we get down low enough in the human scale, shall we not find the fungi of the race, the weakest of our brothers, who have not moral stamina enough to hold their own elected way, but ever show themselves the creatures of circumstances, and are developed into just such moral or immoral characters as their environments suggest? These are the people whose course is always "in the direction of the least resistance," who, if they are placed un-

der good influences, will lead at least quiet and orderly lives, but who are equally plastic to evil, and who will inevitably bloom into criminality if surrounded by lawless associates.

From two persons who have had extensive acquaintance with criminals, as also with those living in ignorance and poverty, which too often prove the approximate cause of crime, we are able to draw conclusive reasons for believing that the instinct of imitation may be used with astonishing effect, if rightly directed over those whose habits have not become irretrievably fixed. The author of "The Juke Family," on the one hand, and the author of "The Dangerous Classes," on the other, have done much to prove this hypothesis. Mr. Dugdale selected for his elaborate analysis the history of an extensive family, some of whom are yet living, whom he calls the Jukes; these he follows through town registers, almshouses, court-records, hospitals, prisons, etc., for six generations, from 1720 to 1872. For greater certainty in tracing the hereditary influence, he follows the female line of descent with the most definite results; his minute research, as to the character and fate of these persons, proves that where any member of the family was removed from the influence and example of crime, either by adoption into or marriage with honest and respectable families, the criminal tendencies disappeared, and the individuals reverted to a reputable life. Thus the imitative faculty was found, even in these cases where vicious blood was a recognized inheritance, to be as active in the imitation of good as of evil ways of living.

Particularly was this the case with those members of this criminal family who escaped from the vicious environment before the age of eighteen—these all took to honest ways, imitating the honest people with whom they lived; notably one who at the age of fifteen married a faithful and industrious German—this branch of the female line never produced a criminal, which was a remarkable exception with the Jukes. Another point bearing on the argument of the propelling influence of imitation is the discovery of the fact that where relatives of the poor have received shelter in almshouses, the children of these more readily resort to them in emergencies than do others in more pressing need, who have had no such record in their families. In fact, pauperism of the chronic kind is more difficult to cure than a tendency to criminality—for the first indicates weakness, the latter vitality.

As a general rule it may be assumed that before maturity the life of every individual is in the main imitative; later, experience and social compulsion reach the reason and teach all persons of average brain-power and moral culture that conformity to the laws of society is in the end more profitable than crime. The exceptions to this rule will be certain to exhibit some form of abnormal development. But the important practical truth is manifest, that while there is *growth in the substance-matter of the brain*, and this organ is acquiring func-

tional habits which are eventually to become automatic mental phenomena, it is of immense importance that every means should then be adopted to eradicate hereditary tendencies to abnormal action of that organ, for while there is growth there may be change of direction, while every year after maturity lessens the chances of this. It may likewise be understood that to a permanent cure of hereditary tendency to crime separation from contaminating example is essential, and this separation must be permanent. Criminals who have acquired habits of industry and self-control during the discipline of a term of imprisonment might reasonably be expected to retain them if placed on their release in conditions which insured paying work and a pure moral atmosphere; but they will inevitably relapse if thrown back into their old circle, where crime and its contrivance are the main business of life. Therefore all discharged convicts, more especially those of the chronic sort, ought to be encouraged, and if necessary aided, to seek a new residence, and by all means persuaded to avoid their old haunts.

That the hereditary taint may be overcome by subsequent training and a lengthened discipline of a judicious kind is proved by the fact that the convicts sent out to Botany Bay by the British Government in general reformed, through the new hopes inspired by new circumstances in a new land, away from their old haunts and habitudes, and their children have reverted to honest and respectable lives. Medical science also shows that the instinctive or ante-natal qualities may be outweighed by the cultivation of the post-natal or reasoning.

It is shown by prison registers and statistics that *sporadic crime* among the educated, and those of honest parentage—that is, in families which have no examples of criminal courses in their direct ancestry—amounts to *but two per cent.*; an overwhelming argument in favor of preventive measures and their value above corrective penalties.

That crime usually *coexists with ignorance and an ill-balanced brain* is shown in the fact that in the large majority of criminals the faculty of arithmetical calculation is almost wholly lacking. Extensive experimental investigations have shown that the average prisoner can not answer the questions, "How much do you make?" "What pay or income would keep you honest?" The reflective qualities are more or less lacking or enfeebled in all descendants from neurotic stock.

Of all the means best adapted for the propagation of crime is that of herding criminals together, especially in juvenile asylums. Several witnesses from the House of Refuge in New York testified that they had there learned from more expert criminals tricks in stealing, picking locks, and in the concealment of stolen goods, which they had never learned outside.

The labors of many philanthropists for the last quarter of a century have shown conclusively that, if the young are seasonably removed from unfavorable environment, but a very small percentage deliberately return to vicious courses; but that they willingly learn

to imitate the industrious and honest habits of their guardians and neighbors, exemplifying the logic of reason, that "an ounce of prevention is better than a pound of cure."

Observing the analogies of nature might teach the social scientist as well as the philanthropist that the measures taken to produce excellence in the animal and vegetable kingdoms are equally applicable to human beings. And what is the course of an arboriculturist or horticulturist if a plant shows abnormal qualities and a tendency to disease? If the owner desires to restore it to a healthy condition, would he allow it to remain among the aborted or monstrous members of its kind? Would he not rather remove it from the soil where its development had proved so unfortunate, to better-selected ground, and to the vicinity of normal healthy plants? So with stock: no breeder of horses or cattle would hope to cure a distemper among his animals if he allowed the diseased to herd together, mutually infecting each other. No, the worst cases he would speedily remove and isolate, and all in succession who showed symptoms likely to result disastrously to themselves or others. The sick would be put into clean quarters, and a more careful system of air and diet provided. Can we expect to cure abnormally developed human beings with less trouble?

The conclusion to be drawn from these considerations of the different phases of crime suggests at least this practical idea: that, *in all stages of education, the proper direction of the will, the due control of the emotions, and the subjection of nervous impulses to the cool judgment of the reason*, are far more important than the mere acquisition of this or that branch of so-called knowledge. A large majority of crimes, particularly crimes of violence, occur because the perpetrators have never been taught or compelled to control their feelings; probably nine tenths of all the crimes, follies, and disasters of which human beings are victims, might be prevented if the youth of the country were habitually instructed in the danger of allowing themselves to be controlled by impulse and feeling—if they could be taught that their nerves and muscles, as well as their desires, should be always under the direction of the intellect or will: and, if this sort of education could supplant that which is usually given to girls and young ladies, might we not hope to see a diminution of that weakly, nervous, hysterical class, which we are almost tempted to rank as criminal, since their very existence is a bane to every family in which they exist? To diminish crimes of all sorts, let the teaching of self-control, the subordination of the emotions to the will, a knowledge of the nervous system, and a worthy, definite object in life, become a part of the education of every youth, male and female. Many crimes which are penally punished are the outcome of semi-insane persons, whose really abnormal condition is not recognized by court or jury, while others are excused as insane when their culminating crime is but the outcome of habitual indulgence of violent temper. Of all the insane, but the

smallest fractional part are the result of excessive intellectual effort; a somewhat larger number arise from structural disease; but the great majority of the insane who have committed or attempted to commit crimes have lost control of their reason because they *habitually allowed passion, not reason, to control them.* Therefore, we repeat, the greatest possible preventive of crime is to raise a race who shall know how to *control their emotional natures* through an enlightened will and the habitual exercise of a moral judgment.

MATERIALISM AND ITS LESSONS.

By Dr. HENRY MAUDSLEY.

IT is well known that from an early period of speculative thought two doctrines have been held with regard to the sort of connection which exists between a man's mind and his body. On the one hand, there are those who maintain that mind is an outcome and function of matter in a certain state of organization, coming with it, growing with it, decaying with it, inseparable from it: they are the so-called materialists. On the other hand, there are those who hold that mind is an independent spiritual essence which has entered into the body as its dwelling-place for a time, which makes use of it as its mortal instrument, and which will take on its independent life when the body, worn out by the operation of natural decay, returns to the earth of which it is made: they are the spiritualists. Without entering into a discussion as to which is the true doctrine, it will be sufficient in this article to accept, and proceed from the basis of, the generally admitted fact that all the manifestations of mind which we have to do with in this world are connected with organization, dependent upon it, whether as cause or instrument; that they are never met with apart from it any more than electricity or any other natural force is met with apart from matter, and that higher organization must go along with higher mental function. What is the state of things in another world—whether the disembodied or celestially embodied spirits of the countless myriads of the human race that have come and gone through countless ages are now living higher lives—I do not venture to inquire. One hope and one certitude in the matter every one may be allowed to have and to express—the hope that, if they are living now, it is a higher life than they lived upon earth; the certitude that, if they are living the higher life, most of them must have had a vast deal to unlearn.

Many persons who readily admit in general terms the dependence of mental function on cerebral structure are inclined, when brought to the particular test, to make an exception in favor of the moral feeling or

conscience. They are content to rest in the uncertain position which satisfied Dr. Abercrombie, the distinguished author of the well-known "Inquiry concerning the Intellectual Powers," who, having pointed out plainly the dependence of mental function on organization, and, as a matter of fact which can not be denied, that there are individuals in whom every correct feeling in regard to moral relations is obliterated, while the judgment is unimpaired in all other relations, stops there without attempting to prosecute inquiry into the cause of the remarkable fact which he justly emphasizes. "That this power," he says, "should so completely lose its sway, while reason remains unimpaired, is a point in the moral constitution of man which it does not belong to the physician to investigate. The fact is unquestionable ; the solution is to be sought in the records of eternal truth." And with this lame and somewhat melancholy conclusion he leaves his readers impotent before a problem which is not only of deep scientific interest, but of momentous practical importance. The observation which makes plain the fact does not, however, leave us entirely without information concerning the cause of it, when we pursue it faithfully, since it reveals as distinct a dependence of moral faculty upon organization as of any other faculty.

Many instructive examples of the pervading mental effects of physical injury of the brain might be quoted, but two or three, recently recorded, will suffice. An American medical man was called one day to see a youth, aged eighteen, who had been struck down insensible by the kick of a horse. There was a depressed fracture of the skull a little above the left temple. The skull was trephined, and the loose fragments of bone that pressed upon the brain were removed, whereupon the patient came to his senses. The doctor thought it a good opportunity to make an experiment, as there was a hole in the skull through which he could easily make pressure upon the brain. He asked the boy a question, and before there was time to answer it he pressed firmly with his finger upon the exposed brain. As long as the pressure was kept up the boy was mute, but the instant it was removed he made a reply, never suspecting that he had not answered at once. The experiment was repeated several times with precisely the same result, the boy's thoughts being stopped and started again on each occasion as easily and certainly as the engineer stops and starts his locomotive.

On another occasion the same doctor was called to see a groom who had been kicked on the head by a mare called Dolly, and whom he found quite insensible. There was a fracture of the skull, with depression of bone at the upper part of the forehead. As soon as the portion of bone which was pressing upon the brain was removed the patient called out with great energy, "Whoa, Dolly!" and then stared about him in blank amazement, asking: "Where is the mare? Where am I?" Three hours had passed since the accident, during

which the words which he was just going to utter when it happened had remained locked up, as they might have been locked up in the phonograph, to be let go the moment the obstructing pressure was removed. The patient did not remember, when he came to himself, that the mare had kicked him; the last thing before he was insensible which he did remember was, that she wheeled her heels round and laid back her ears viciously.

Cases of this kind show how entirely dependent every function of mind is upon a sound state of the mechanism of the brain. Just as we can, by pressing firmly upon the sensory nerve of the arm, prevent an impression made upon the finger being carried to the brain and felt there, so by pressing upon the brain we can as certainly stop a thought or a volition. In both cases a good recovery presently followed the removal of the pressure upon the brain; but it would be of no little medical interest to have the after-histories of the persons, since it happens sometimes after a serious injury to the head that, despite an immediate recovery, slow, degenerative changes are set up in the brain months or years afterward, which go on to cause a gradual weakening, and perhaps eventual destruction, of mind. Now the instructive matter in this case is that the moral character is usually impaired first, and sometimes is completely perverted, without a corresponding deterioration of the understanding; the person is a thoroughly changed character for the worse. The injury has produced disorder in the most delicate part of the mental organization, that which is separated from actual contact with the skull only by the thin investing membranes of the brain; and, once damaged, it is seldom that it is ever restored completely to its former state of soundness. However, happy recoveries are now and then made from mental derangement caused by physical injury of the brain. Some years ago a miner was sent to the Ayrshire District Asylum, who, four years before, had been struck to the ground insensible by a mass of falling coal, which fractured his skull. He lay unconscious for four days after the accident, then came gradually to himself, and was able in four weeks to resume his work in the pit. But his wife noticed a steadily increasing change for the worse in his character and habits; whereas he had formerly been cheerful, sociable, and good-natured, always kind and affectionate to her and his children, he now became irritable, moody, surly, suspicious, shunning the company of his fellow workmen, and impatient with her and the children. This bad state increased; he was often excited, used threats of violence to his wife and others, finally became quite maniacal, attempted to kill them, had a succession of epileptic fits, and was sent to the asylum as a dangerous lunatic. There he showed himself extremely suspicious and surly, entertained a fixed delusion that he was the victim of a conspiracy on the part of his wife and others, and displayed bitter and resentful feelings. At the place where the skull had been fractured there was a well-marked depres-

sion of bone, and the depressed portion was eventually removed by the trephine. From that time an improvement took place in his disposition, his old self coming gradually back; he became cheerful again, active and obliging, regained and displayed all his former affection for his wife and children, and was at last discharged recovered. No plainer example could be wished to show the direct connection of cause and effect—the great deterioration of moral character produced by the physical injury of the supreme nerve-centers of the brain: when the cause was taken away the effect went also.

Going a step further, let me point out that disease will sometimes do as plain and positive damage to moral character as any which direct injury of the brain will do. A fever has sometimes deranged it as deeply as a blow on the head; a child's conscience has been clean effaced by a succession of epileptic convulsions, just as the memory is sometimes effaced; and those who see much of epilepsy know well the extreme but passing moral transformations that occur in connection with its seizures. The person may be as unlike himself as possible when he is threatened with a fit; although naturally cheerful, good-tempered, sociable, and obliging, he becomes irritable, surly, and morose, very suspicious, takes offense at the most innocent remark or act, and is apt to resent imaginary offenses with great violence. The change might be compared well with that which happens when a clear and cloudless sky is overcast suddenly with dark and threatening thunder-clouds; and just as the darkly clouded sky is cleared by the thunder-storm which it portends, so the gloomy moral perturbation is discharged and the mental atmosphere cleared by an epileptic fit or a succession of such fits. In a few remarkable cases, however, the patient does not come to himself immediately after the fit, but is left by it in a peculiar state of quasi-somnambulism, during which he acts like an automaton, doing strange, absurd, and sometimes even criminal things, without knowing apparently at the time what he is doing, and certainly without remembering in the least what he has done when he comes to himself. Of excellent moral character habitually, he may turn thief in one of these states, or perpetrate some other criminal offense by which he gets himself into trouble with the police.

There are other diseases which, in like manner, play havoc with moral feeling. Almost every sort of mental derangement begins with a moral alienation, slight perhaps at the outset, but soon so great that a prudent, temperate, chaste, and truthful person shall be changed to exactly the opposite of what he was. This alienation of character continues throughout the course of the disease, and it is frequently found to last for a while after all disorder of intelligence has gone. Indeed, the experienced physician never feels confident that the recovery is stable and sure, until the person is restored to his natural sentiments and affections. Thus it appears that when mind undergoes decadence, the moral feeling is the first to suffer; the highest acquisi-

tion of mental evolution, it is the first to witness to mental degeneracy. One form of mental disease, known as general paralysis, is usually accompanied with a singularly complete paralysis of the moral sense from the outset; and a not uncommon feature of it, very striking in some cases, is a persistent tendency to steal, the person stealing in a weak-minded manner what he has no particular need of, and makes no use of when he has stolen it. The victim of this fatal disease is frequently sent to prison and treated as a common criminal in the first instance, notwithstanding that a medical man who knows his business might be able to say with entire certitude that the supposed criminal was suffering from organic disease of the brain, which had destroyed moral sense at the outset, which would go on to destroy all the other faculties of his mind in succession, and which in the end would destroy life itself. There is no question in such case of moral guilt; it is not sin but disease that we are confronted with; and after the victim's death we find the plainest evidence of disease of brain, which has gone along with the decay of mind. Had the holiest saint in the calendar been afflicted as he was, he could not have helped doing as he did.

I need not dwell any longer upon the morality-sapping effects of particular diseases, but shall simply call to mind the profound deterioration of moral sense and will which is produced by the long-continued and excessive use of alcohol and opium. There is nowhere a more miserable specimen of degradation of moral feeling and of impotence of will than the debauchee who has made himself the abject slave of either of these pernicious excesses. Insensible to the interests of his family, to his personal responsibilities, to the obligations of duty, he is utterly untruthful and untrustworthy, and in the worst end there is not a meanness of pretense or of conduct that he will not descend to, not a lie he will not tell, in order to gain the means to gratify his overruling craving. It is not merely that passion is strengthened and will weakened by indulgence as a moral effect, but the alcohol or opium which is absorbed into his blood is carried by it to the brain and acts injuriously upon its tissues: the chemist will, indeed, extract alcohol from the besotted brain of the worst drunkard, as he will detect morphia in the secretions of a person who is taking large doses of morphia. Seldom, therefore, is it of the least use to preach reformation to these people, until they have been restrained forcibly from their besetting indulgence for a long enough period to allow the brain to get rid of the poison, and its tissues to regain a healthier tone. Too often it is of little use then; the tissues have been damaged beyond the possibility of complete restoration. Moreover, observation has shown that the drink-craving is oftentimes hereditary, so that a taste for the poison is ingrained in the tissues, and is quickly kindled by gratification into uncontrollable desire.

Thus far it appears, then, that moral feeling may be impaired or

destroyed by direct injury of the brain, by the disorganizing action of disease, and by the chemical action of certain substances which, when taken in excess, are poisons to the nervous system. When we look sincerely at the facts, we can not help perceiving that it is just as closely dependent upon organization as is the meanest function of mind; that there is not an argument to prove the so-called materialism of one part of mind which does not apply with equal force to the whole mind. Seeing that we know no more essentially what matter is than what mind is, being unable in either case to go beyond the phenomena of which we have experience, it is of interest to ask why the spiritualist considers his theory to be of so much higher an intellectual and moral order than materialism, and looks down with undisguised pity and contempt on the latter as inferior, degrading, and even dangerous; why the materialist should be deemed guilty, not of intellectual error only, but of something like moral guilt. His philosophy has been lately denounced as a "philosophy of dirt." An eminent prelate of the English Church, in an outburst of moral indignation, once described him as possibly "the most odious and ridiculous being in all the multiform creation"; and a recent writer in a French philosophical journal uses still stronger language of abhorrence: "I abhor them," he says, "with all the force of my soul. . . . I detest and abominate them from the bottom of my heart, and I feel an invincible repugnance and horror when they dare to reduce psychology and ethics to their bestial physiology—that is, in short, to make of man a brute, of the brute a plant, of the plant a machine. . . . This school is a living and crying negation of humanity." The question is, what there is in materialism to warrant the sincere feeling and earnest expression of so great a horror of it. Is the abhorrence well founded, or is it, perhaps, that the doctrine is hated, as the individual oftentimes is, because misunderstood?

This must certainly be allowed to be a fair inquiry by those who reflect that no less eminent a person and good a Christian than Milton was a decided materialist. Several scattered passages in "Paradise Lost" plainly betray his opinions; but it is not necessary to lay any stress upon them, because in his "Treatise on Christian Doctrine" he sets them forth in the most plain and uncompromising way, and supports them with an elaborate detail of argument. He is particularly earnest to prove that the common doctrine that the spirit of man should be separate from the body, so as to have a perfect and intelligent existence independently of it, is nowhere said in Scripture, and is at variance both with nature and reason; and he declares that "man is a living being, intrinsically and properly one and individual, not compound and separable, not, according to the common opinion, made up and framed of two distinct parts, as of soul and body." Another illustrious instance of a good Christian who for a great part of his life avowed his belief that "the nature of man is simple and uni-

form, and that the thinking power and faculties are the result of a certain organization of matter," was the eloquent preacher and writer, Robert Hall. It is true that he abandoned this opinion at a later period of his life; indeed, his biographer tells us with much satisfaction that "he buried materialism in his father's grave"; and a theological professor in an American college has in a recent article exultantly claimed this fact as triumphant proof that the materialist's "gloomy and unnatural creed" can not stand before such a sad feeling as grief at a father's death. One may be excused, perhaps, for not seeing quite so clearly as these gentlemen the soundness of the logic of the connection. On the whole, logic is usually sounder and stronger when it is not under the pressure of great feeling.

The truth is, that a great many people have the deeply-rooted feeling that materialism is destructive of the hope of immortality, and dread and detest it for that reason. When they watch the body decay and die, considering furthermore that after its death it is surely resolved into the simple elements from which all matter is formed, and know that these released elements go in turn to build up other bodies, so that the material is used over and over again, being compounded and decompounded incessantly in the long stream of life, they can not realize the possibility of a resurrection of the individual body. They can not conceive how matter, which has thus been used over and over again, can remake so many distinct bodies, and they think that to uphold a bodily resurrection is to give up practically the doctrine of a future life. It is a natural but not a necessary conclusion, as the examples of Milton and Robert Hall prove, since they, though materialists, were devout believers in a resurrection of the dead. Moreover, there are many vehement antagonists of materialism who readily admit that it is not inconsistent with the belief in a life after death. Indeed, they could not well do otherwise when they recollect what the Apostle Paul said in his very energetic way, addressing the objector to a bodily resurrection as "Thou fool!" and what happened to the rich man who died and was buried; for it is told of him that "in hell he lifted up his eyes and cried and said, 'Father Abraham, have mercy on me, and send Lazarus that he may dip the tip of his finger in water and cool my tongue, for I am tormented in this flame.'" Now, if he had eyes to lift up and a tongue to be cooled, it is plain that he had a body of some kind in hell; and if Lazarus, who was in another place, had a finger to dip in water, he also must have had a body of some kind there.

Leaving this matter, however, without attempting to explain the mystery of the body celestial, I go on to mention a second reason why materialism is considered to be bad doctrine. It is this: that with the rise and growth of Christianity there came in the fashion of looking down on the body with contempt as the vile and despicable part of man, the seat of those fleshly lusts which warred against the higher

aspirations of the soul. It was held to be the favorite province of the devil, who, having intrenched himself there, lay in wait to entice or to betray to sin; the wiles of Satan and the lusts of the flesh were spoken of in the same breath, as in the service of the English Church prayer is made for "whatsoever has been decayed by the fraud and malice of the devil, or by his own carnal will and frailness"; and all men are taught to look forward to the time when "he shall change this vile body and make it like unto his glorious body." It was the extreme but logical outcome of this manner of despising the body to subject it to all the penances, and to treat it with all the rigor, of the most rigid asceticism—to neglect it, to starve it, to scourge it, to mortify it in every possible way. One holy ascetic would never wash himself, or cut his toe-nails, or wipe his nose; another suffered maggots to burrow unchecked into the neglected ulcers of his emaciated body; others, like St. Francis, stripped themselves naked and appeared in public without clothes. St. Macarius threw away his clothes and remained naked for six months in a marsh, exposed to the bite of every insect; St. Simeon Stylites spent thirty years on the top of a column which had been gradually raised to a height of sixty feet, spending a great part of his time in bending his meager body successively with his head toward his feet, and so industriously that a curious spectator, after counting twelve hundred and forty-four repetitions, desisted counting from weariness. And for these things—these insanities of conduct may we not call them?—they were accounted most holy, and received the honors of saintship. Contrast this unworthy view of the body with that which the ancient Greeks took of it. They found no other object in nature which satisfied so well their sense of proportion and manly strength, of attractive grace and beauty; and their reproductions of it in marble we preserve now as priceless treasures of art, albeit we still babble the despicable doctrine of contempt of it. The more strange, since it is a matter of sober scientific truth that the human body is the highest and most wonderful work in nature, the last and best achievement of her creative skill; it is a most complex and admirably constructed organism, "fearfully and wonderfully made," which contains, as it were in a microcosm, all the ingenuity and harmony and beauty of the macrocosm. And it is this supreme product of evolution that fanatics have gained the honor of saintship by disfiguring and torturing!

These, then, are two great reasons of the repugnance which is felt to materialism, namely, the notion that it is destructive of the hope of a resurrection, and the contempt of the body which has been inculcated as a religious duty. And yet on these very points materialism seems fitted to teach the spiritualist lessons of humility and reverence, for it teaches him, in the first place, not to despise and call unclean the last and best work of his Creator's hand; and, secondly, not impiously to circumscribe supernatural power by the narrow limits of

his understanding, but to bethink himself that it were just as easy in the beginning, or now, or at any time, for the omnipotent Creator of matter and its properties to make it think as to make mind think.

Passing from these incidental lessons of humility and reverence, I go on now to show that materialism has its moral lessons, and that these, rightly apprehended, are not at all of a low intellectual and moral order, but, on the contrary, in some respects more elevating than the moral lessons of spiritualism. I shall content myself with two or three of these lessons, not because there are not more of them, but because they will be enough to occupy the space at my disposal.

It is a pretty well accepted scientific doctrine that our far-distant prehistoric ancestors were a very much lower order of beings than we are, even if they did not inherit directly from the monkey; that they were very much like, in conformation, habits, intelligence, and moral feeling, the lowest existing savages; and that we have risen to our present level of being by a slow process of evolution which has been going on gradually through untold generations. Whether or not "through the ages one increasing purpose runs," as the poet has it, it is certainly true that "the thoughts of men are widened with the process of the suns." Now, when we examine the brain of the lowest savage, whom we need not be too proud to look upon as our ancestor in the flesh—say a native Australian or a Bushman—we find it to be considerably smaller than an ordinary European brain; its convolutions, which are the highest nerve-centers of mind, are decidedly fewer in number, more simple in character, and more symmetrical in arrangement. These are marks of inferiority, for in those things in which it differs from the ordinary European brain it gets nearer in structure to the still much inferior brain of the monkey; it represents, we may say, a stage of development in the long distance which has been traversed between the two. A comparison of the relative brain-weights will give a rude notion of the differences: the brain-weight of an average European male is forty-nine ounces; that of a Bushman is, I believe, about thirty-three ounces; and that of a negro, who comes between them in brain-size, as in intelligence, is forty-four ounces. The small brain-weight of the Bushman is indeed equaled among civilized nations by that of a small-headed or so-called microcephalic idiot. There can be no doubt, then, of a great difference of development between the highest and the lowest existing human brain.

There can be no doubt, furthermore, that the gross differences which there are between the size and development of the brain of a low savage and of an average European, go along with as great differences of intellectual and moral capacities—that lower mental function answers to lower cerebral structure. It is a well-known fact that many savages can not count beyond five, and that they have no words in their vocabulary for the higher qualities of human nature, such as virtue, justice, humanity, and their opposites, vice, injustice, and

cruelty, or for the more abstract ideas. The native Australian, for example, who is in this case, having no words for justice, love, mercy, and the like, would not in the least know what remorse meant; if any one showed it in his presence, he would think probably that he had got a bad headache. He has no words to express the higher sentiments and thoughts because he has never felt and thought them, and has never had, therefore, the need to express them; he has not in his inferior brain the nervous substrata which should minister to such sentiments and thoughts, and can not have them in his present state of social evolution, any more than he could make a particular movement of his body if the proper muscles were wanting. Nor could any amount of training in the world, we may be sure, ever make him equal in this respect to the average European, any more than it could add substance to the brain of a small-headed idiot and raise it to the ordinary level. Were any one, indeed, to make the experiment of taking the young child of an Australian savage and of bringing it up side by side with an average European child, taking great pains to give them exactly the same education in every respect, he would certainly have widely different results in the end: in the one case he would have to do with a well-organized instrument, ready to give out good intellectual notes and a fine harmony of moral feeling when properly handled; in the other case, an imperfectly organized instrument, from which it would be out of the power of the most patient and skillful touch to elicit more than a few feeble intellectual notes and a very rude and primitive sort of moral feeling—a little better feeling, certainly, than that of its fathers, but still most primitive; for many savages regard as virtues most of the big vices and crimes, such as theft, rape, murder, at any rate when they are practiced at the expense of neighboring tribes. Their moral feeling, such as it is, is extremely circumscribed, being limited in application to the tribe. In Europe we have happily got further than that, since we are not, as savages are and our forefathers probably were, divided into a multitude of tribes eager to injure and even extirpate one another from motives of tribal patriotism; but mankind seems to be far off the goal of its high calling so long as, divided into jealous and hostile nations, it suffers national divisions to limit the application of moral feeling, counts it a high virtue to violate it under the profaned name of patriotism, and uses the words "humanitarianism" and "cosmopolitanism" as crushing names of reproach. There is plainly room yet for a wider expansion of moral feeling.

Now, what do the discoveries of science warrant us to conclude respecting the larger and more complex brain of the civilized man and its higher capacities of thought and feeling? They teach us this: that it has reached its higher level not by any sudden and big creative act, nor by a succession of small creative acts, but by the slow and gradual operation of processes of natural evolution going on through

countless ages. Each new insight into natural phenomena on the part of man, each act of wiser doing founded on truer insight, each bettered feeling which has been developed from wiser conduct, has tended to determine by degrees a corresponding structural change of the brain, which has been transmitted as an innate endowment to succeeding generations, just as the acquired habit of a parent animal becomes sometimes the instinct of its offspring; and the accumulated results of these slow and minute gains, transmitted by hereditary action, have culminated in the higher cerebral organization, in which they are now, as it were, capitalized. Thus the added structure embodies in itself the superior intellectual and moral capacities of abstract reasoning and moral feeling which have been the slow acquisitions of the ages, and it gives them out again in its functions when it discharges its functions rightly. If we were to have a person born in this country with a brain of no higher development than that of the low savage—destitute, that is, of the higher nervous substrata of thought and feeling—if, in fact, our far remote prehistoric ancestors were to come to life among us now—we should have more or less of an imbecile, who could not compete on equal terms with other persons, but must perish, unless charitably cared for, just as the native Australian perishes when he comes into contact and competition with the white man. The only way in which the native Australian could be raised to the level of civilized feeling and thought would be by cultivation continued through many generations—by a process of evolution similar to that which lies back between our savage ancestors and us.

That is one aspect of the operation of natural law in human events—the operation of the law of heredity in development, in carrying mankind forward, that is, to a higher level of being. It teaches us plainly enough that the highest qualities of mind bear witness to the reign of law in nature as certainly as do the lowest properties of matter, and that if we are to go on progressing in time to come, it must be by observation of, and obedience to, the laws of development. But there is another vastly important aspect of the law of heredity, which it concerns us to bear sincerely in mind—its operation in working out human degeneracy, in carrying mankind downward, that is, to a lower level of being. It is certain that man may degenerate as well as develop; that he has been doing so both as nation and individual ever since we have records of his doings on earth. There is a broad and easy way of dissolution, national, social, or individual, which is the opposite of the steep and narrow way of evolution. Now, what it behooves us to realize distinctly is, that there is not anything more miraculous about the degeneracy and extinction of a nation or of a family than there is about its rise and development; that both are the work of natural law. A nation does not sink into decadence, I presume, so long as it keeps fresh those virtues of character through which it became great among nations; it is when it suffers them to be eaten away

by luxury, corruption, and other enervating vices, that it undergoes that degeneration of character which prepares and makes easy its overthrow. In like manner a family, reckless of the laws of physical and moral hygiene, may go through a process of degeneracy until it becomes extinct. It was no mere dream of prophetic frenzy that when the fathers have eaten sour grapes the children's teeth are set on edge, nor was it a meaningless menace that the sins of the fathers shall be visited upon the children unto the third and fourth generations; it was an actual insight into the natural law by which degeneracy increases through generations—by which one generation reaps the wrong which its fathers have sown, as its children in turn will reap the wrong which it has sown. What we call insanity or mental derangement is truly, in most cases, a form of human degeneracy, a phase in the working out of it; and, if we were to suffer this degeneracy to take its course unchecked through generations, the natural termination would be sterile idiocy and extinction of the family. A curious despot would find it impossible, were he to make the experiment, to breed and propagate a race of insane people; Nature, unwilling to continue a morbid variety of the human kind, would bring his experiment to an end by the production of sterile idiocy. If man will but make himself the subject of serious scientific study, he shall find that this working out of degeneracy through generations affords him a rational explanation of most of those evil impulses of the heart which he has been content to attribute to the wiles and instigations of the devil; that the evil spirit which has taken possession of the wicked man is often the legacy of parental or ancestral error, misfortune, or wrong-doing. Let me illustrate by an example the nature and bearing of this scientific study.

I will take for this purpose a case which every physician who has had much experience must have been asked some time or other to consider and advise about: a quite young child, which is causing its parents alarm and distress by the precocious display of vicious desires and tendencies of all sorts, that are quite out of keeping with its tender years, and by the utter failure of either precept, or example, or punishment to imbue it with good feeling and with the desire to do right. It may not be notably deficient in intelligence; on the contrary, it may be capable of learning quickly when it likes, and extremely cunning in lying, in stealing, in gratifying other perverse inclinations; and it can not be said not to know right from wrong, since it invariably eschews the right and chooses the wrong, showing an amazing acuteness in escaping detection and the punishment which follows detection. It is, in truth, congenitally conscienceless, by nature destitute of moral sense and actively imbued with an immoral sense. Now, this unfortunate creature is of so tender an age that the theory of satanic agency is not thought to offer an adequate explanation of its evil impulses; in the end everybody who has to do with it feels that it is not responsible for its vicious conduct, perceives that

punishment does not and can not in the least reform it, and is persuaded that there is some native defect of mind which renders it a proper case for medical advice. Where, then, is the fault that a human being is born into the world who will go wrong, nay, who must go wrong, in virtue of a bad organization? The fault lies somewhere in its hereditary antecedents. We can seldom find the exact cause and trace definitely the mode of its operation—the study is much too complex and difficult for such exactness at present—but we shall not fail to discover the broad fact of the frequency of insanity or other mental degeneracy in the direct line of the child's inheritance. The experienced physician seldom feels any doubt of that when he meets with a case of the kind. It is indeed most certain that men are not bred well or ill by accident any more than the animals are; but, while most persons are ready to acknowledge this fact in a general way, very few pursue the admission to its exact and rigorous consequences, and fewer still suffer it to influence their conduct.

It may be set down, then, as a fact of observation that mental degeneracy in one generation is sometimes the evident cause of an innate deficiency or absence of moral sense in the next generation. The child bears the burden of its ancestral infirmities or wrong-doings. Here, then, and in this relation, may be noted the instructive fact that just as moral feeling was the first function to be affected at the beginning of mental derangement in the individual, so now the defect or absence of it is seen to mark the way of degeneracy through generations. It was the latest acquisition of mental evolution; it is the first to go in mental dissolution.

A second fact of observation may be set down as worthy of consideration, if not of immediate acceptation, namely, that an absence of moral feeling in one generation, as shown by a mean, selfish, and persistent disregard of moral action in the conduct of life, may be the cause of mental derangement in the next generation. In fact, a person may succeed in manufacturing insanity in his progeny by a persistent disuse of moral feeling, and a persistent exercise throughout his life, of those selfish, mean, and anti-social tendencies which are a negation of the highest moral relations of mankind. He does not ever exercise the nervous substrata which minister to moral functions, wherefore they undergo atrophy in him, and he runs the risk of transmitting them to his progeny in so imperfect a state that they are incapable of full development of function in them; just as the instinct of the animal which is not exercised for many generations on account of changed conditions of life, becomes less distinct by degrees and in the end, perhaps, extinct. People are apt to talk as if they believed that insanity might be got rid of were only sufficient care taken to prevent its direct propagation by the marriages of those who had suffered from it or were likely to do so. A vain imagination assuredly! Were all the insanity in the world at the present time clean swept

away to-morrow, men would breed it afresh before to-morrow's to-morrow by their errors, their excesses, their wrong-doings of all sorts. Rightly, then, may the scientific inquirer echo the words of the preacher, that however prosperous a man may have seemed in his life, judge him not blessed before his death; for he shall be known in his children: they shall not have the confidence of their good descent. In sober truth, the lessons of morality which were proclaimed by the prophets of old, as indispensable to the stability and well-being of families and nations, were not mere visions of vague fancy; founded upon actual observation and intuition of the laws of nature working in human events, they were insights into the eternal truths of human evolution.

Whether, then, man goes upward or downward, undergoes development or degeneration, we have equally to do with matters of stern law. Provision has been made for both ways; it has been left to him to find out and determine which way he shall take. And it is plain that he must find the right path of evolution, and avoid the wrong path of degeneracy, by observation and experience, pursuing the same method of positive inquiry which has served him so well in the different sciences. Being preëminently and essentially a social being, each one the member of one body—the unit, that is, in the social organism—the laws which he has to observe and obey are not the physical laws of nature only, but also those higher laws which govern the relations of individuals in the social state. If he make his observations sincerely and adequately in this way, he can not fail to perceive that the laws of morality were not really miraculous revelations from heaven any more than was the discovery of the law of gravitation, but that they were essential conditions of social evolution, and were learned practically by the stern lessons of experience. He has learned his duty to his neighbor as he has learned his duty to nature; it is implicit in the constitution of a complex society of men dwelling together in peace and unity, and has been revealed explicitly by the intuition of a few extraordinary men of sublime moral genius.

As it is not a true, it can not be a useful, notion to foster that morality was the special gift to man, and is the special property of any theological system, and that its vitality is bound up essentially with the life of any such creed. The golden rule of morals itself—"Do unto others as ye would have others do unto you"—was perceived and proclaimed long before it received its highest Christian expression.* It is not, indeed, religious creed which has invented and been the basis of morality, but morality which has been the bulwark

* There appears to be no doubt that Confucius, among others, had the clearest apprehension of it and expressly taught it; and the Buddhist religion of perfection is certainly founded upon self-conquest and self-sacrifice. They are its very corner-stone: the purification of the mind from unholy desires and passions, and a devotion to the good of others, which rises to an enthusiasm for humanity, in order to escape from the miseries of

of religions. And as a matter of fact it is certain that morality has suffered many times not a little from its connection with theological creeds; that its truths have been appropriated and used to support demoralizing superstitions which were no part of it; that doctrines essentially immoral have been even taught in the name of religion; and that religious systems, in their struggles to establish their supremacy, have oftentimes shown small respect to the claims of morality. Had religion been true to its nature and function, as wide as morality and humanity, it should have been the bond of unity to hold mankind together in one brotherhood, linking them in good feeling, good will, and good work toward one another; but it has in reality been that which has most divided men, and the cause of more hatreds, more disorders, more persecutions, more bloodshed, more cruelties, than most other causes put together. In order to maintain peace and order, therefore, the state in modern times has been compelled to hold itself practically aloof from religion, and to leave to each hostile sect liberty to do as it likes so long as it meddles not by its tenets and ceremonials with the interests of civil government. Is it not, then, fortunate for the interests of morality that it is not bound up essentially with any form of religious creed, but that it survives when creeds die, having its more secure foundations in the hard-won experience of mankind?

The inquiry which, taking a sincere survey of the facts, finds the basis and sanction of morality in experience, by no means arrives in the end at easy lessons of self-indulgence for the individual and the race, but, on the contrary, at the hardest lessons of self-renunciation. Disclosing to man the stern and uniform reign of law in nature, even in the evolution and degeneracy of his own nature, it takes from him the comfortable but demoralizing doctrine that he or others can escape the penalty of his ignorance, error, or wrong-doings either by penitence or prayer, and holds him to the strictest account for them. Discarding the notion that the observed uniformity of nature is but a uniformity of sequence at will, which may be interrupted whenever its interruption is earnestly enough asked for—a notion which, were it more than lip-doctrine, must necessarily deprive him of his most urgent motive to study patiently the laws of nature in order to conform to them—it enforces a stern feeling of responsibility to search out painfully the right path of obedience and to follow it, inexorably laying upon man the responsibility of the future of his race. If it be most certain, as it is, that all disobedience of natural law, whether physical or moral, is avenged inexorably in its consequences on earth, either upon the individual himself, or more often, perhaps, upon oth-

this life and to attain to a perfect moral repose. "Let all the sins that have been committed fall upon me, in order that the world may be delivered," Buddha says. And of the son or disciple of Buddha it is said: "When reviled he reviletb not again; when smitten he bears the blow without resentment; when treated with anger and passion he returns love and good-will; when threatened with death he bears no malice."

ers—that the violated law can not be bribed to stay its arm by burnt-offerings nor placated by prayers—it is a harmful doctrine, as tending directly to undermine understanding and to weaken will, to teach that either prayer or sacrifice will obviate the consequences of want of foresight or want of self-discipline, or that reliance on supernatural aid will make amends for lack of intelligent will. We still pray half-heartedly in our churches, as our forefathers prayed with their whole hearts, when we are afflicted with a plague or pestilence, that God will "accept of an atonement and command the destroying angel to cease from punishing"; and when we are suffering from too much rain we ask him to send fine weather, "although we for our iniquities have worthily deserved a plague of rain and waters." Is there a person of sincere understanding who, uttering that prayer, now believes it in his heart to be the successful way to stay a fever, plague, or pestilence? He knows well that, if it is to be answered, he must clean away dirt, purify drains, disinfect houses, and put in force those other sanitary measures which experience has proved to be efficacious, and that the aid vouchsafed to the prayer will only be given when these are by themselves successful. Had men gone on believing, as they once believed, that prayer would stay disease, they would never have learned and adopted sanitary measures, any more than the savage of Africa who prays to his fetich to cure disease does now. To get rid of the notion of supernatural interposition was the essential condition of true knowledge and self-help in that matter.

Many persons who could not confidently express their belief in the power of prayer to stop a plague or a deluge of rain, or who actually disbelieve it, still have a sincere hold of the belief of its miraculous power in the moral or spiritual world. Nevertheless, if the matter be made one simply of scientific observation, it must be confessed that all the evidence goes to prove that the events of the moral world are matters of law and order equally with those of the physical world, and that supernatural interpositions have no more place in the one than in the other; that he who prays for the creation of a clean heart and the renewal of a right spirit within him, if he gets at last what he prays for, gets it by the operation of the ordinary laws of moral growth and development, in consequence of painstaking watchfulness over himself and the continual exercise of good resolves. Only when he gets it in that way will he get the benefit of supernatural aid; and, if he rests in the belief of supernatural aid, without taking pains to get it entirely in that way, he will do himself moral harm; for if he can not rely upon special interpositions in the moral any more than in the physical world, if he has to do entirely with those secondary laws of nature through which alone the supernatural is made natural, the invisible visible, it needs no demonstration that the opposite belief can not strengthen, but must weaken, the understanding and will. It is plain that true moral hygiene is as impossible to the savage who relies

upon his fetich to change his heart in answer to prayer, as sanitary science is impossible where he relies upon his fetich to stay a pestilence in answer to prayer.

So far from materialism being a menace to morality, when it is properly understood, it not only sets before man a higher intellectual aim than he is ever likely to reach by spiritual paths, but it even raises a more self-sacrificing moral standard. For when all has been said, it is not the most elevated or the most healthy business for a person to be occupied continually with anxieties and apprehensions and cares about the salvation of his own soul, and to be earnest to do well in this life in order that he may escape eternal suffering and gain eternal happiness in a life to come. The disbeliever might find room to argue that here was an instance showing how theology has taken possession of the moral instinct and vitiated it. Having set before man a selfish instead of an altruistic end as the prime motive of well-doing—his own good rather than the good of others—it is in no little danger of taking away his strongest motive to do uprightly, if so be the dead rise not. Indeed, it makes the question of the apostle a most natural one: "If, after the manner of men, I have fought with beasts at Ephesus, what advantageth it me if the dead rise not?" Materialism can not hesitate in the least to declare that it is best for a man's self, and best for his kind, to have fought with the beasts of unrighteousness at Ephesus or elsewhere, even if the dead rise not. Perceiving and teaching that he is essentially a social being, that all the mental faculties by which he so much excels the animals below him, and even the language in which he expresses his mental functions, have been progressive developments of his social relations, it enforces the plain and inevitable conclusion that it is the true scientific function, and at the same time the highest development, of the individual to promote the well-being of the social organization; that is, to make his life subserve the good of his kind. It is no new morality, indeed, which it teaches; it simply brings men back to that which has been the central lesson and the real stay of the great religions of the world, and which is implicit in the constitution of society; but it does this by a way which promises to bring the understanding into entire harmony with moral feeling, and so to promote by a close and consistent interaction their accordant growth and development; and it strips morality of the livery of superstition in which theological creeds have dressed and disfigured it, presenting it to the adoration of mankind in its natural purity and strength.—*Fortnightly Review.*

THE BIRTH, LIFE, AND DEATH OF A STORM.*

By ROBERT H. SCOTT, M.A., F.R.S., Etc.

WHEN we are asked to give an account of the birth of a storm, we are reluctantly compelled to admit that our storms are, almost without exception, foundlings, and that, as the precise conditions to which they owe their origin are, for the most part, shrouded in uncertainty, warm discussions at times arise as to the parish whence they have set out on their wanderings.

Dove said long ago that storms were due to the interference of the polar current or the east wind with the equatorial current or west wind. He gave the winds these names, because on his views the east winds really consisted of air flowing from the north or south pole toward the equator, which was modified in the direction of its motion by its change of latitude; while west winds were really due to air endeavoring to make its way back to the pole from the equator, whose course was in its turn modified by its moving from lower to higher latitudes. To the conflict of these two grand currents, east and west winds, Dove attributed all our storms; but he did not attempt to explain how the currents came into collision.

These views, however correct on their cosmical principles, have been superseded, of late years at least, as regards the explanation of our winds, by the modern views of the relation between the wind and the distribution of barometrical pressure; but, unfortunately, we still remain in comparative ignorance of the ultimate causes to which this distribution of pressure, or the rise and fall of the barometer, are due. To give some conception of the existing difference of opinion on these fundamental principles of our science, I may say that while some authorities maintain that the force of the wind in a hurricane is caused by the amount of barometrical disturbance which accompanies it, others hold that the fall of the barometer at the center is itself, in great measure, due to the centrifugal force of the revolving mass of air.

Of the various theories which have been propounded to account for storms, which are generally more or less cyclonic in their character, I shall only mention four:

1. Some authorities, and among them our own countryman the Rev. Clement Ley, attribute the formation and subsequent progress of a storm to the condensation of moisture, but they apparently ignore the fact that many of our very heaviest rains do not give rise to cyclonic disturbances of serious character. For instance, when on April 10 and 11, 1878, 4·6 inches of rain fell at Haverstock Hill, we had no

* Founded on a lecture delivered by the author at the London Institution, February 3, 1879.

storm of wind at all. In partial confirmation of this view, Professor Mohn, of Christiania, points to the accidental condensation of moisture caused by the contact of a mass of damp air with the surface of an extensive snow-field as a possible cause of a storm. About the sixty-first parallel of latitude the glacier region of Justedal stretches for several miles along the coast of Norway, and this has occasionally been known to exert an influence in increasing the intensity of an existing cyclone, and even in some instances has appeared as the center of a newly-formed depression.

These gentlemen, moreover, rely greatly on the fact that the rain area which accompanies every cyclonic system is roughly oval in shape, with its longer axis extending in the direction in which the system is advancing, and that by far the greatest amount of rain falls in front of the storm. They do not, however, explain the fact that very heavy rain frequently occurs on the northern side of a depression, where the wind is easterly, and that this circumstance does not indicate a northward motion of the system.

The most serious objection to this theory is, however, that first stated, that not only do the heaviest rains not come with the severest storms, but that frequently they are observed in times of nearly absolute calm.

2. The second theory to which I shall refer is the mechanical one, most strongly urged by Mr. Meldrum, of the Mauritius, whose investigations into the weather over the Indian Ocean have led him to the belief that every cyclone is generated in the intervening space between two oppositely flowing currents of air, of which the easterly moving stream, speaking in the most general terms, lies on the polar side of the westerly wind. Such a disposition of the currents would be that which would naturally arise were the cyclone once formed.

This view is called seriously in question by Messrs. Blanford and Eliot in their discussion of recent cyclones in the Bay of Bengal, which they have been able to study from very early stages, and in which they fail to see evidence of the preëxistence of two, and only two, determinate currents.

Another serious objection to this theory is that it does not assign a *vera causa* sufficient to give the *first* impetus to the barometrical fall and the rotatory movement of the air.

3. A third theory of the origin of these storms is that which is strongly urged by M. Faye, in Paris, and is to the effect that, as interfering currents in rivers give rise to vortices which extend from the surface downward into the water, so all our water-spouts, *trombes*, and even the largest tropical hurricanes must be all formed in the upper regions of the atmosphere, and extend downward to the earth: the force which gives them their onward motion being supplied by the upper currents.

It is sufficient to say that this theory has not met with acceptance

from any practical meteorologist, while it is directly controverted by recent investigations into the motion of cirrus clouds, which show beyond a doubt that the motion of the upper currents of air over a cyclone is outward, and not inward, as the descending theory would demand.

Moreover, some of our readers may have noticed, in "Nature" of January 16th, a notice, copied from the "Times," of the formation on the Lake of Geneva, on January 2d, of a veritable small water-spout, forty feet high and ten yards in circumference, by the meeting of two winds, known locally as the *Föhn* and the *Bise*, on the surface of the lake. Here the water-spout was raised, and did not descend from the clouds.

4. The last theory we shall notice is that of the late Mr. Thomas Belt, who seeks for the origin of the disturbance on the ground, and, like M. Faye, assigns the same explanation to the smallest dust-whirl eddies and the largest storms which sweep over the earth.

This theory assumes as the first cause the heat of the sun. The heat-rays pass through the atmosphere without warming the upper strata, and so Mr. Belt supposed that over a sandy soil a mass of air close to the ground might rise in temperature much higher than the superincumbent layers of the atmosphere. The lower strata would therefore become lighter, and a condition of unstable equilibrium would arise. This, however, could not last for ever, and, sooner or later, the heated lower air would burst up, and the ascending column thus produced would be the nucleus of the nascent cyclone.

The difficulty in accepting this explanation is, that we should like some ocular evidence of such a sequence of conditions. The supporters of the theory, however, point to accredited instances of the formation of whirlwinds over volcanoes like Santorin, and over extensive fires like those of Carolina canebrakes.

In confirmation of these views of the effect of solar heat in producing a depression, I may cite an investigation by Dr. Hamberg, of Upsala, who has found that in July, 1872, after a prevalence of intensely warm weather in southern Sweden, pressure gave way over the heated area, the isobaric lines following the trend of the coast; and a rotatory movement was thereby generated in the atmosphere above it, resulting in a perfectly formed cyclone which passed on over northern Finland. It would appear, therefore, that the production of a cyclonic disturbance may be attributable to more than one agency, as all the theories mentioned have some facts in their favor.

Leaving, then, this abstruse and imperfectly understood line of inquiry, let us proceed to a subject which yields us results of more immediate practical utility: the character and history of the storms when they have once started on their travels. I shall commence by saying that a greater mistake can not be made than to assert that *all* storms are distinctly connected with cyclonic disturbances.

The force of the wind depends on differences of atmospherical pres-

sure over a given area, and the only reason why storms are generally associated with cyclones is that these systems afford us the most serious instances of disturbances of atmospheric equilibrium, and consequently of differences of pressure, which are met with on the globe.

At any place where an area of relatively high pressure comes into close proximity to an area of relatively low pressure, a gale will result, and so a storm may be due just as much to the rise of the barometer in one region as to its fall in an adjacent district. For the same physical reason, however, that the eddies in a river extend downward, and the water does not pile itself up in a peak, the normal disturbance of atmospherical equilibrium is the appearance of one of these vortices with pressure decreasing rapidly toward the center. Wherever there is a rapid decrease there is a steep gradient, and consequently a strong wind.

Defining the term cyclone, in its very widest acceptation, as indicating a region of diminished pressure, round and in upon which the air is moving along paths which are more symmetrical all round the center the more perfect is the circular form of the system, we must at once see that not every cyclone is accompanied by a storm. The fact is, that the direction and force of the wind are regulated by the difference of barometrical pressure over a given distance, and not in any way by the actual height of the barometer at the station at which the storm is felt, or by the distance of that station from the point where the barometrical reading for the time being is the lowest.

This explanation of wind-motion is almost the only new principle which has been recognized in our science during the present generation, and its practical importance is daily forcing itself more and more into public notice with the development of weather telegraphy. It is usually known under the name of Buys Ballot's Law, and is stated as follows: "Stand with your back to the wind, and the barometer will be lower on your left hand than on your right." The truth of this law is evident to any one who looks at a weather chart; but the Dutch Professor, after whom it is named, though he justly claims the credit of having persistently advocated the acceptance of this relation of the wind to the distribution of pressure, was not by any means the first to discover it.

The final result of all the inquiries into the question is, that on the mean of all winds the angle between their direction and the tangent to the isobar at the place is about 20°.

These principles of wind-motion have a most important bearing on the theory of the motion of the air in hurricanes and typhoons. The old popular idea of these phenomena is, that the air blew round and round the central calm in circles, so that any sailor caught in one of these storms could at once know that when he was hove-to, if he looked in the wind's eye, the center bore eight points to the right in the northern hemisphere, and to the left in the southern; or, what is the same

thing, if he was scudding before the wind, the center would lie exactly on the starboard beam in the northern and on the port beam in the southern hemisphere.

Modern meteorologists, however, almost with one voice, declare for a spirally incurving movement as the most probable behavior of the wind, as would be indicated by the angle which its direction makes with the isobars as just explained; but this view presents no novelty, for it was first stated about forty years ago, and Piddington, in his "Sailor's Hornbook," says that even Redfield, when propounding his "Law of Storms," stated:

"I have never been able to conceive that the wind in violent storms moved only in circles. On the contrary, a vortical movement, approaching to that which may be seen in all lesser vortices, aërial or aqueous, appears to be an essential element of their violent and long-continued action, of their increased energy toward the center of axis, and of the accompanying rain. In conformity with this view, the storm-figure on my chart of the storms of 1830 was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver."

We see, therefore, that when we trace back to its origin the belief that any storms are really circular, we find that it was "the convenience of an engraver" which decided the question.

It may be safely asserted that there does not exist, for a single instance of a West Indian hurricane or China Sea typhoon, a sufficiency of evidence to convince any unprejudiced investigator as to what was the true path of the air in the storm. To show this path beyond the possibility of doubt, we require a considerable number of simultaneous observations taken on different sides of the storm center. These, however, were not forthcoming in the case of a single storm described by Redfield, Reid, or Piddington, so that the authority of the founders of the law of storms can not be cited as decisive of the question.

This suggestion of spiral motion must of course modify the simple rule for a ship scudding, of looking in the wind's eye, and taking eight points on the starboard or port side for the storm center, and indicates the probability that the true position of that spot will be at least two or three points ahead of the bearing given by that rule, so that the ship, if scudding, *may be* gradually approaching the most dangerous part of the storm.

The recent investigations of Mr. Meldrum, which have been thoroughly confirmed by Captain Toynbee's examination of the Nova Scotia storm of August 24, 1873, lead to the suspicion, not to use a stronger word, that these cyclonic storms are not symmetrical at all, and that at some parts of the system the wind blows directly toward the center, so that for a ship in such a situation, and scudding before the wind, the center would lie right ahead.

This is a subject which requires most careful study, in order to see

whether or not the time-honored rules for handling ships in rotating storms require modification.

I shall now leave the subject of the air-motion, and proceed to describe the phenomena of a cyclonic disturbance when it passes over us. In the first place, very few of them, in these latitudes, exhibit much approach to a circular shape, as regards the course of the inner isobars, and we may say that none of them develop equal violence in all segments. The reason of these differences in the force of the wind is to be found in the distribution of pressure in the vicinity of the storm area, for if on any side of that area there exists a region of high barometer readings, on that side steep gradients will be produced, and of course proportionably great violence of the wind. The actual weather phenomena of a typical cyclonic disturbance, if plotted on a diagram, show very clearly how cloud and rain prevail over the whole front of the system, and how in the rear, where the wind is northwesterly, the sky clears up. There is one fact worth remembering about these storms, and that is, that just before the sky clears a very smart squall of rain frequently comes on; so that we get this practical hint: if, during a westerly gale, we find the rain becoming exceptionally heavy, we may look for the weather speedily to clear up.

Such a diagram also shows us that it is quite a mistake to consider all east winds as dry ones, for in a cyclonic system the cloud area extends on the northern side, where the wind is easterly, nearly as much as on the southern, where the wind is from the westward. In fact, many of our wettest days occur with easterly winds, when one of these depressions passes to the south of the station where we may be.

I shall now proceed to give a slight sketch of what we have learned of the movement of storms. This, as far as we can see, is regulated by the position of the areas of high pressure, or, as they are called, the anticyclones. This is a term introduced about fifteen years ago by Mr. Francis Galton, to indicate an area of excess of pressure out from which the air is slowly whirling with a motion opposite to that which it has in cyclones. If we find an anticyclonic area existing over any region, we know that the cyclonic disturbances will skirt round it and develop their strongest wind on the side which lies closest to the district of high pressure.

Thus if the anticyclone lies over France, the cyclonic disturbances will move from west to east over the British Isles. If the area of high pressure lies over England, the depressions will sweep outside the Scotch coast, and reach Norway north of the sixtieth parallel. If the anticyclone lies to the westward, and the pressure is higher in Ireland than in Great Britain, there is danger of northerly gales on the east coast of England, from cyclonic disturbances traveling southward over the North Sea.

In every case the cyclone moves with the prevailing wind along its track.

Unfortunately, we know very little about the rate at which these storms advance, some of them moving at the extraordinary speed of fifty or sixty miles an hour, as for instance that of March 12, 1877; while others, like the West India hurricanes, do not attain one fourth of that rapidity of translation. It is remarkable that the rate of progress bears no relation to the intensity of the storm, the slow-moving tropical hurricanes being infinitely more violent than many of our rapidly-moving disturbances; although the storm already mentioned in March, 1877, was severe enough, at least in the north of France, to satisfy any requirements.

As regards the distance which storms have been known to travel, I may cite a very long-lived storm, which lasted nearly a fortnight in August, 1873, and which was traced along its course by my friend Captain Toynbee, by means of the logs of two hundred and sixty ships which were in the Atlantic during its continuance. Its history will be found in the last published work of the Meteorological Office, "The Weather over the Atlantic Ocean during August, 1873." This particular storm wrought immense damage on the coast of Nova Scotia. It did not, however, travel as far as Europe, having disappeared in the neighborhood of Newfoundland. In fact, very few storms have really been proved to maintain their individuality during their transit. Professor Loomis, an American meteorologist, who has devoted much attention during the last twenty years to the connection between European and American weather, has very recently published a paper on the results of discussion of two years' daily synoptic charts of the Atlantic. During that interval thirty-six areas of depression were traceable across the Atlantic, that is, at the rate of eighteen a year. Testing these by wind reports from England alone, he finds that the chance that a storm center coming from the United States will strike England is only one in nine; of its causing a gale anywhere near the English coast it is one in six; while the chance of its causing a strong breeze is an even one.

This brings us to a subject which has attracted an immense amount of public attention in this country and in France: the practical value of the warnings which have been sent over by the "New York Herald" during the last two years. By "practical value" I mean the value to our fishermen and coasting sailors, for whose benefit, more than for that of seagoing men in large vessels, the whole system of storm-warnings has been called into being. It is evident that a warning which is locally unfulfilled may mean a loss of some hundreds of pounds to a fishing fleet; and although the storm to which it referred may have reached some parts of the coasts of Europe, yet if it did not visit the precise district where the fishing was being prosecuted at the time, the fishermen in that district were not benefited by the warning. On the contrary, they were the worse for having received it, on the old principle that "Wolf! wolf!" should not be cried too often.

Of course, every word that I here say as to the usefulness of warnings is just as true with reference to warnings issued by our own office in London as to those of the "New York Herald," but these latter are often very general in their scope. They speak occasionally of a storm reaching the British Isles and France, and affecting Norway. This haul of the net embraces 25° of latitude, from 45° to 70°, and it is an unheard-of thing that a gale should prevail simultaneously over such an immense tract of coast, so that on each occasion the seamen in many harbors can not derive immediate benefit from the publication of so vague an announcement.

It is one thing for a scientific man to say that he can recognize the presence of the predicted cyclone on our coast—Professor Loomis admits that the chances are even that he should do so—but it is a totally different matter to prove that a gale which begins two days before or two days after the time of a predicted storm, is really the very disturbance which left the American coasts.

The experience of those who have studied cyclone tracks in northern Europe shows that in winter, on an average, a cyclonic disturbance visits some parts of those regions every fourth day, so that, if a warning were announced once a week regularly, there would be nearly a certainty of some sort of a fulfillment.

The results of a most careful comparison of these warnings with the weather experienced by us during the years 1877–'78 are given by the following percentage figures:

	1877		1878	
Absolute success	17·5	42·5	27·0	45·0
Partial success	25·0		18·0	
Partial failure	15·0	57·5	10·0	55·0
Absolute failure	42·5		45·0	

In order to obtain so favorable a result as forty-five per cent. of general success, great allowances have been made. Thus it has been considered an absolute success if a gale was felt on *any* part of the coast, whereas the prediction was for *all* parts; and when three separate storms were predicted in one telegram, none of which arrived, only one failure has been counted.

It is, therefore, pretty clear that these warnings have not, as yet, proved themselves to be of much practical utility to our coasting trade and our fishermen. The question is a most interesting one, and although a satisfactory solution of it has not been attained, we need not despair; but we should attack it from the scientific side, and discuss the results in a calm, dispassionate spirit, and through some other medium than that of letters to newspapers.

Let us now leave these American warnings, and see what we know about the movement of storms over western Europe, which is the problem which most immediately concerns us here. The illustration has often been used that meteorologists, in issuing storm-warnings, and

having to estimate the direction and rate of motion of every storm the instant it shows itself in their neighborhood, are in the position of astronomers expected to assign the path of a comet from the first glimpse they get of it through a break in a cloud—a problem which all will allow to be impossible of solution. Accordingly, great interest attaches to the attempts made from time to time to lay down principles for forecasting the motion of the disturbance.

I have already stated that, as a general rule, the cyclones move round the anticyclones; but this principle requires for its application to storm-warning purposes, access to charts embracing a very considerable extent of the earth's surface. These are very difficult for Englishmen to obtain, as our own daily charts are very limited in area, and frequently do not exhibit even the whole extent of a single cyclonic depression, much less its relation to the distribution of pressure all about it. For those, however, who can consult such charts it is possible, so to speak, to take their stand at a higher point of view and survey the conditions prevailing, say over Europe, on any given day.

If the amount of change in the pressure or of rise and fall of the barometer during the preceding night be plotted every morning on such a chart, it is found that the path of the system for the day does not lie directly toward the region where the greatest fall has occurred during the night, but is regulated to a certain extent by the direction of the line drawn from the point of greatest fall to that of greatest rise.

Another theory of storm-motion, strongly held by those who attribute all our storms to condensation of vapor, is that the track of the depression is always directed toward the region where the air is dampest. This principle, like that just noticed, can hardly be turned to account in this country for our own practical benefit, inasmuch as the whole of these islands appear to be almost equally damp, owing to the proximity of most of our telegraphic reporting stations to the sea.

Other suggestions have been made in various quarters, with the view of throwing light on this very important subject; but we can not say that the results have met with general acceptance, and the matter urgently demands further study.

I must now come to the final portion of my theme—the death of a storm; and on this subject, unfortunately, I have very little to say. As we have not been able to produce evidence of the birth of a storm, so have we never been lucky enough to find any one who was in at the death. In fact, some French meteorologists have hazarded the statement that storms can travel all round the world until at last they travel off it.

Storms have been traced from the Pacific coast of North America across the Atlantic; but these instances are necessarily rare, and, as far as European experience goes, no storm arriving from the Atlantic ever travels far into Russia. This fact is, of course, very much in favor of the condensation theory of storm generation, which has already

been noticed. The advocates of this view plead very plausibly that, as the moisture in the air is the food of the storm, so, where that moisture is deficient, the storm dies of starvation.

We may, however, point out to them that eddies in a river and dust-whirls at street corners waste and wane without any assistance from vapor condensation.

In conclusion, though it is a humiliating confession for us to make, meteorologists are as yet entirely in the dark as to the reasons why one depression fills up while another becomes deeper. As I have already stated, no meteorologist is able to give a straightforward answer to the simple question, What causes the barometer to rise or fall?—*Popular Science Review.*

BIOGRAPHICAL NOTICE OF GEORGE F. BARKER.

PROFESSOR BARKER, who is this year President of the American Scientific Association, was born in Charlestown, Massachusetts, July 14, 1835. His parents were in comfortable circumstances, his father being in command of a packet-ship sailing between Boston and Liverpool. His early education was received in the public schools of his native place, though before graduating at the high school the family removed in 1849 to South Berwick, Maine, and he continued his studies, first at the Classical Academy in that village, and subsequently at the Lawrence Academy in Groton, Massachusetts, and at Yarmouth Academy, Maine. In 1851 he accepted an invitation from his father to visit the Crystal Palace International Exhibition in London. On his return he entered, as an apprentice, the shop of the Hon. J. M. Wightman, of Boston, the well-known maker of philosophical instruments, where he remained until he attained his majority in 1856. Faraday was not so fortunate; he was an apprentice to a bookbinder, whereas young Barker was indentured to a trade that laid the foundation of his scientific education.

In September of that year, by the advice of friends, he entered the Yale Scientific School (now the Sheffield School) in New Haven as a student in chemistry, and was graduated therefrom with the degree of Bachelor of Philosophy in 1858. During the last year of this course of study he held the position of Professor Silliman's chemical assistant; and during the winter of 1858–'59, and again in 1860–'61, he was assistant to Dr. John Bacon, Professor of Chemistry in the Harvard Medical School, Boston. In 1859, at the Springfield meeting, he was made a member of the American Association for the Advancement of Science. In the winter of the same year he gave, on invitation, a course of public lectures in the city of Pittsburg, under the

auspices of the Western University of Pennsylvania. In the summer of 1860 he again visited Europe, spending his time while abroad mainly in studying the scientific collections, institutions, and resources of London and Paris.

During the month of August, 1861, on the recommendation of his friend President Hitchcock, of Amherst College, he was tendered the professorship of Natural Science in Wheaton College, Illinois. This he accepted, and discharged the duties of the chair for the subsequent college year. In September, 1862, he went to Albany, at the solicitation of his friend Professor C. H. Porter, to act as his substitute in the chair of Chemistry in the Albany Medical College, Professor Porter having entered the army as Assistant Surgeon of Volunteers. While thus acting, he pursued regularly his medical studies, and was graduated therefrom as a Doctor of Medicine in 1863. After a third course of chemical lectures in Albany, given in the fall of 1864, Professor Barker went to Pittsburg as Professor of Natural Science in the Western University, remaining there during one year.

In the winter of 1865–'66, while preparing to enter the service of the United States as an Assistant Surgeon of Volunteers, having been offered a commission by Dr. Quackenbush, then Surgeon-General of the State of New York, he was offered by Professor Silliman the position of Demonstrator of Chemistry in the Yale Medical College. This offer was accepted, and he entered immediately upon his duties. Early in the spring of 1866 Professor Barker wrote the first part of a text-book, intended as a new edition of Silliman's "Chemistry." In this book, the modern nomenclature and notation appeared in a text-book for the first time in this country. The theory of types was made use of as a basis of classification, and the book was used with the senior class in Yale College.

During the absence of Professor Silliman in California in 1866–'67, the entire instruction in chemistry, in the Academical Department of Yale, was given by Dr. Barker. At the commencement in 1867, he was appointed Professor of Physiological Chemistry and Toxicology in the Medical Institution of Yale College. The chemical lectures in Williams College, in the absence of an instructor in that science, were given by him in the spring of the years 1868 and 1869. In the summer of 1870 he wrote a chemical manual entitled "A Text-book of Elementary Chemistry," which was published in September. In this book it was assumed that one philosophy was broad enough for the whole of chemical science; and hence the subject was divided into four sections—Theoretical, Inorganic, Organic, and Physiological—only the first two of which were presented in the volume mentioned. It achieved a very considerable success, about ten thousand copies having been sold within the five years after its publication, and translations of it into French and into Japanese having been made. It was adopted as the text-book in the University of Tokio, Japan. In

December, 1871, Professor Barker delivered a lecture before the American Institute in New York, upon the "Correlation of Vital and Physical Forces," which attracted very general attention. The lecture was an attempt to show that, besides the ordinary psychological definition of mind, another and a purely physiological one might be found, which represented mind as solely the product of brain-action, and, as such, entirely capable of being correlated with physical forces. In 1872 he was Vice-President of the American Association at its Indianapolis meeting.

Having made the branch of toxicology the subject of special study, Professor Barker was engaged quite generally in the investigation of cases of criminal poisoning. Perhaps the most important of these cases was the celebrated one in which Lydia Sherman was tried in New Haven, in April, 1872, for poisoning her husband with arsenic. Because the Wharton case, tried just before, had apparently left upon the public mind the impression that chemical analysis in such cases was unreliable, and hence had given the criminally disposed some reason to believe that they might commit murder by poison with impunity, especial care was taken by Dr. Barker to present the chemical and physiological evidence in the Sherman case in a fully conclusive form. To the thoroughness of this preparation, and the completeness of the chemical evidence, the conviction of the prisoner was largely due. The chemical evidence in this trial, after correction by him, was inserted in full, as a typical case, in the subsequent edition of Wharton and Stillé's "Medical Jurisprudence."

In February, 1873, he was strongly urged to accept the chair of Physics in the University of Pennsylvania, Philadelphia. After due consideration and consultation the offer was accepted, and he removed from New Haven to Philadelphia in April. The trustees having placed a generous sum of money at his disposal, for the purpose of providing the apparatus necessary for illustrating the science in a proper manner, Professor Barker left in July for Europe, in order to personally inspect the instruments he was about to purchase. The result has justified this step. The collection of physical apparatus in the university cabinet is certainly unsurpassed in this country, and in some directions it is absolutely unique in the world.

In the fall of 1876 Professor Barker had the distinguished honor of being elected a member of the National Academy of Sciences. In the summer of 1878, on invitation of Professor Henry Draper, he accompanied the Draper Eclipse Expedition to Rawlins, Wyoming, where he studied the total solar eclipse of July 29th, as spectroscopic observer. The most important fact obtained by him was the confirmation of Janssen's observation of 1871, that the coronal spectrum contained the dark solar lines of Fraunhofer. After the eclipse he accompanied his friend Thomas A. Edison on a trip to California and the Yosemite. He stopped on his return to attend the meeting of the

American Association for the Advancement of Science, held at St. Louis. He was there elected President of the Association for the next meeting, to be held at Saratoga, August 27, 1879.

Professor Barker has well earned his distinctions, but he is to be congratulated on having also obtained them. He has been the recipient of many deserved honors, and now, in middle life, after a twenty years' membership, he is called upon to preside over the deliberations of the largest scientific body in the country, and to fill the chair that has been occupied by all of our ablest scientific men.

Professor Barker manifested at a very early age a taste for the sciences which he has subsequently cultivated so successfully. While yet a boy he was intrusted with the apparatus belonging to the academies where he was at school, and converted his sleeping-room into a chemical laboratory. As an apprentice he extended his acquaintance with instrumental appliances, and constructed for himself in his leisure hours a very complete set of electrical and pneumatic apparatus. The familiarity with the use of tools, and the knowledge of the construction of instruments thus acquired, have no doubt been of the greatest practical benefit to him in subsequent life. Indeed, it is said that, when he went to Pittsburg as professor, much of the apparatus placed in his hands for purposes of instruction was the identical apparatus which he had made in Boston as an apprentice ten or twelve years before. Though upon his graduation from Yale he made chemistry his profession, turning his attention more particularly to its physiological relations after taking his doctor's degree, he yet kept up his interest in physics, especially in the departments of electricity and spectroscopy, until upon his removal to Philadelphia he made physics the subject of his instructions, though still keeping up his knowledge of chemistry.

Professor Barker's reputation as a chemist rests chiefly upon his work in chemical theory, he having been among the first in this country to appreciate the advantages of the new views, to use them in his own work, and to teach them to his students. In physics his spectroscopic work upon the metals, upon auroras, and upon the phenomena of solar eclipses has been of high scientific value. But it is as an instructor in science that the chief part of his time has been spent. Not only in the class-room and the laboratory with his students, but also in the public lecture-room, and before the largest audiences, has his power of elucidation and illustration gained for him preëminence. He has served as scientific expert in a number of noted patent cases. He has acted as one of the chemical editors of the "American Journal of Science and Arts" since July, 1877, having prepared the abstracts of chemical papers which were published in that Journal since 1868. He was editor of the "Journal of the Franklin Institute" during 1874-'75; and he prepared, at the request of Professor Baird, the chemical and physical notes for the "Scientific Rec-

ord" of "Harper's Magazine," and for the "Annual" for many years. We subjoin a list of the most important of the scientific papers which he has published :

1. "The Forces of Nature"; a Lecture before the Chemical Society of Union College. (Albany, 1863.)

2. "Account of the Casting of a Gigantic Rodman Gun at Pittsburg" (American Journal of Science, II., xxxvii., 296, April, 1864).

3. "Report of a Trial for Poisoning by Strychnia" (American Journal of Medical Sciences, October, 1864).

4. "Formic *versus* Carbonous Acid" (American Journal of Science, II., xliv., 263, October, 1867).

5. "On Normal and Derived Acids" (American Journal of Science, II., xliv., 384, November, 1867).

6. "A Text-book of Elementary Chemistry, Theoretical and Inorganic" (New Haven, 1870).

7. "Notices of Papers in Physiological Chemistry" (American Journal of Science, II., xlvi., 233, 379; xlvii., 20, 258, 393; xlviii., 49).

8. "Abstract of the Second Series of Meissner's Researches on Electrized Oxygen" (American Journal of Science, II., l., 213, September, 1870).

9. "On Molecular Classification" (American Chemist, i., 359, April, 1871).

10. "On the Rational Formulas of the Oxides of Chlorine and of Oxides analogously constituted" (American Chemist, ii., 1, July, 1871).

11. "Note on the Spectrum of the Aurora" (American Journal of Science, III., ii., 465, December, 1871).

12. "Correlation of Vital and Physical Forces"; a Lecture before the American Institute. (New York, 1871.)

13. "The Chemical Testimony in the Sherman Poisoning Case" (American Chemist, ii., 441, June, 1872).

14. "On the Spectrum of the Aurora of October 14, 1872" (American Journal of Science, III., v., 81, February, 1873).

15. "A New Vertical Lantern Galvanometer" (Proceedings of the American Philosophical Society, xiv., 440, May, 1875).

16. "The Molecule and the Atom"; an Address to the Chemical Subsection of the American Association for the Advancement of Science, at the Buffalo meeting (Proceedings of the American Association for the Advancement of Science, xxv., 85, August, 1876).

17. "Results of the Spectroscopic Observation of the Solar Eclipse of July 29, 1878"; a Report to the Director, Dr. Henry Draper (American Journal of Science, III., xvii., 121, February, 1879).

18. "On a New Method of measuring the Pitch of a Tuning-Fork" (Proceedings of the American Association for the Advancement of Science, xxvii., 118, August, 1878).

19. "On the Total Solar Eclipse of July 29, 1878" (Proceedings of the American Philosophical Society, xviii., 103, November, 1878).

CORRESPONDENCE.

A COMPLAINT ABOUT THE MONTHLY.

Messrs. Editors.

WILL you permit a brief criticism of your selections for "The Popular Science Monthly"? My appreciation of the journal is sufficiently indicated in its reception and careful reading from the time it was begun. I have for some fifty years tried to do my own thinking—not so self-sufficiently, however, that I am not very glad to get what true help I can from other thinkers.

I have been attracted to "The Popular Science Monthly" by the evident desire and purpose of its conductors to give a fair hearing to all views, *pro* or *con*, on any subject of general scientific interest. There is one, however, now before the world which, in importance to the whole human family, can be assigned to no second place, which, in my view, you treat in a very partisan manner. I refer to the Harmonial Philosophy, Spiritualism, or whatever it may be called. This question, whether evolving truths of the deepest importance to humanity, or a species of insanity, delusion, or imposition, demands attention and discussion; for millions of people are to-day affected more or less by its phenomena and teachings, and it is spreading with a rapidity unrealized by the indifferent observer. From its first opening with the Fox girls near Rochester, New York, to the present, I have observed it closely, and often under very favorable circumstances. To endorse it *en masse* would to me be folly; to utterly ignore it, equally so.

I am fully satisfied that there are great and most important truths involved in the subject, which demand elimination from what may be accompanying rubbish. Now, when you select for "The Popular Science Monthly" articles all, or nearly so, on one side of this question, and from men like Hammond, Beard, Gairdner, Trowbridge, etc., you leave the path of true science for that of the partisan.

To me, as well as several other readers of the journal with whom I have communicated, a *fair* discussion of this subject would not only add interest, but remove a present offense. You might lose some bigoted and fossilized readers, but you would gain an equal if not larger number of the less prejudiced.

A. L. CHILD, M. D.

PLATTSMOUTH, NEBRASKA, *May* 30, 1879.

"WASTED FORCES."

Messrs. Editors.

IN an article on "Wasted Forces" by William H. Wahl, Ph. D., in "The Popular Science Monthly" for July, 1879, I note some remarkable statements in that part of the article which deals with the efficiency of steam-engines. The writer seems to have ignored the principal cause of wasted heat in the steam-engine, viz., the efficiency of the fluid, and to have augmented the other losses in order, apparently, to account for the low efficiency of the whole machine. In doing this he has given figures, which not only leave wrong impressions in the minds of those not familiar with the subject, but he makes opportunities for improvement seem far greater in some directions than they are. I do not care to call in question the fifteen per cent. which Mr. Wahl gives as the greatest efficiency yet obtained from steam-engines, but in locomotive-engines, with which I am most familiar, five per cent. will more nearly represent the efficiency of average performance. Granting that fifteen per cent. may be obtained in the most economical engines, it is to Mr. Wahl's method of accounting for the loss of eighty-five per cent. that I object. On page 292 one reads: "For by far the greater portion of this eighty-five per cent. of wasted power is chargeable directly to the steam-boiler, and but a comparatively small proportion thereof to the engine." And again, on page 293: "Summing up all the items of loss in the steam-generator, it is probable that with the best forms of boiler which it has been possible to construct, not more than twenty-five per cent. of the theoretical thermal effect of the fuel is utilized in the generation of steam; and of this twenty-five per cent., from five to ten per cent. is lost somewhere on the passage of the steam from the boiler to and through the engine by condensation in steam-pipes, and friction of the machinery, leaving us but fifteen or twenty per cent. actually realized in practice." As a matter of fact I have repeatedly observed from fifty to fifty-five per cent. of the total theoretical number of heat-units obtainable from the complete combustion of bituminous coal transferred to the water and steam in the boiler from locomotive fire-boxes, in which the proper burning of coal is far more difficult than in stationary fire-boxes, or those with natural draught and ample room; in such fire-boxes as last mentioned, coal is

burned so as to transfer from seventy to seventy-five per cent. of its theoretical heat to the boiler, and I do not know that this is the best attainable. Mr. Wahl's limit of twenty-five per cent. efficiency of fire-box, or, as he well terms the boiler and fire-box, the "steam-generator," is therefore entirely too low; neither has he mentioned the principal cause of the loss of heat in steam-engines, viz., the low efficiency of steam as a medium on account of its high latent heat, a very small part of which, at best, can be utilized even in condensing engines, and still less in non-condensing engines. In locomotive-engines the following statement will represent a fair average performance, with corresponding approximate rates of loss from different causes:

Efficiency of steam-generator........	55 per ct.
Efficiency of steam and steam-engine.	8 "
Efficiency of machine .55 × .8=......	4.4 "

The low efficiency of the steam stands somewhat as follows:

Units of heat required to convert one pound of water from 60° Fahr. to steam at 125 pounds' pressure........................	1,160
Of which the latent heat is................	865

which can not be converted into work in the locomotive-engine: neither is the difference $1,160 - 865 = 295$ all available; for $212 - 60 = 152$ of this was required to heat the pound of water to the boiling-point at atmospheric pressure, and still more at one hundred and twenty-five pounds' pressure. This reduces to $295 - 152 = 143$ units, all of which is not obtained from each 1,160 units expended, for the steam is exhausted at some pressure above atmosphere to get more work from the engine and to blow the fire, so that we really get but about ninety useful units out of 1,160 expended, or about eight per cent. In best stationary engines (which are to yield fifteen per cent. efficiency) this would stand:

Efficiency of generator, approx...	75 per cent.
Efficiency of steam and engine "	20 "
Efficiency of whole machine, .75 × .20=15	"

The twenty per cent. here in place of the eight per cent. in locomotives is because of expanding steam to a lower pressure before exhausting, of the partial vacuum ahead of piston from condensing exhaust steam, and of the heated feed-water which should be credited to this account of efficiency of steam. I can not here go into the experiments of M. Hirn, and conclusions therefrom, on the beneficial influence of partial condensation on steam side of piston, but the above figures, so far as they go, will nearly represent the facts of efficiency. I think you will do your readers a service by correcting, even in this general way, the wrong impressions they may have received from Mr. Wahl's figures.

John W. Cloud.

Altoona, Pennsylvania, *July* 5, 1879.

A WONDERFUL PHENOMENON ACCOUNTED FOR.

Messrs. Editors.

I see by your correspondence that there is some interest taken in spiritualism.

A case occurred in my experience some fifteen years ago which, for a while, made a profound impression on my mind. My house is situated about three hundred feet from a large church, which has a fine organ, that we heard more or less, when played upon.

It was in the beginning of summer; the windows being open, myself and family heard more plainly than common, as we thought at first, the organ. It went through a chord producing at times what is called the *tremolo*. We soon ascertained, however, that these sounds did not come from the organ, but from the piano which stood in our double parlors. It went through a chord of quite a number of the lower notes, giving somewhat the sound of the organ. Being myself rather skeptical in matters pertaining to superhuman phenomena, I was touched profoundly by these manifestations.

Some of the more timid neighbors declared they would not live in the house; myself and family did not share these views. I stated to my friends that I expected to find some rational cause for this most extraordinary phenomenon. People wanted to come in droves to witness this new wonder, which I did not allow. Some spiritualists came from Boston, ten miles, to hear for themselves, and declared it must be produced by spirits from the other world. To this I could not assent, never having believed in spiritualism.

The Rev. Eli Fay, Unitarian, and now settled at Sheffield, England, and the Rev. Dr. J. C. Bodwell, Orthodox, now dead, both able, discreet men, spent with me considerable time in investigating the cause of these wonderful sounds. They examined the house throughout, including the cellar, without success. On one occasion one of my neighbors, being present, made the inquiry, "Who have played most on your piano, who are now dead?" My answer was, his own wife, now dead, and the daughter of one of my near neighbors. He then replied, "Is it possible that Caroline's spirit" (meaning his wife) "is there?"—when the piano seemed to go through a chord louder than ever before, and almost made the hair stand erect on our heads.

And so it continued for some days, until one evening I sat on the front stairs reading the evening paper, there being no gas burning in the house except in the hall, and my family were out. My attention was attracted to a very different sound, not musical, coming apparently from the piano. I stepped into the parlors—still the noise continued. I now lighted the gas in the parlors, when im-

mediately the original harmony was renewed. It now occurred to me that the gas must produce some vibratory effect upon the strings of the piano and therefore was the cause of these extraordinary sounds. In support of this the sounds were heard only in the evening, which gave the whole affair an additional strangeness.

This proved to be the key that unlocked the whole mystery. I soon found the piano had nothing to do with it, notwithstanding myself and friends had repeatedly listened at the piano when the cover was both open and shut, and it seemed to proceed direct from the instrument. On further investigation the sounds were traced to the gas-meter which was in the cellar, nearly under the piano. The sound, though diffused somewhat, had seemed to be in the piano.

After a short time my family became tired of these sounds, and I had the gas meter changed for another, and have never heard them since.

I could have made a great sensation of this matter, but did not. I have no doubt that many mysterious things have taken place which have been ascribed to some supernatural cause, when persistent intelligent investigation would have solved the whole affair in a rational way. Truly,

John Clough.

Woburn, Massachusetts, *July* 15, 1879.

EDITOR'S TABLE.

SPIRITUALISM AGAIN.

WE print a translation of Professor Wundt's letter to Ulrici, which has attracted a good deal of attention in Germany, and is quite as applicable here as there. The view taken is one that needs enforcing, and it is satisfactory to find that it completely agrees with what has been repeatedly urged upon the subject in our pages.

We print also a communication from Dr. Child, of Nebraska, complaining of our partisanship in publishing upon only one side of this subject. He asks that we give audience to the spiritualists because it is our habit to accord "a fair hearing to all views, *pro* or *con*, on any subject of general scientific interest." But he here overlooks a very important distinction. We give the *pros* and *cons* only of subjects that are within the legitimate sphere of science. We give the *pros* and *cons* of discussion only where imperfect knowledge leads to diverse views, and where both sides recognize the canons of evidence by which all science has been created. But, though admitting of controversy under this limitation, our journal is devoted to the interests of science, and it can not be denied that we *are* partisans—partisans of the multiplication-table, partisans of the law of gravity, partisans of science generally. Our magazine was started expressly to represent this side of things, and we have no right to publish the other side—that is, anti-scientific papers; it would be a breach of contract with subscribers.

Our correspondent offers as a reason why we should open our columns to spiritualism, the fact that millions of people are becoming affected by its teachings, while it is spreading with unsuspected rapidity. That is a reason which might be addressed to ambitious politicians, who are always powerfully impressed by numbers, or to sectarian adventurers looking out for recruits; but it can not weigh in the court of science, where there is but one interest, the establishment of scientific truth. To the scientific mind, spiritualism is much the same whatever its magnitude. Science is satisfied to operate on small quantities, so they are fair samples, and for its purposes, one roomful of mediums is as good as a hundred. The believers in the power of ghosts and spirits have always been in the majority, and will no doubt long continue to be so. Does not our correspondent see that this rapid extension of spiritualism links it on to popular ignorance and credulity, and cuts it off from intelligence? Does he not see that he is

dealing with the old superstition in a new form, and which spreads by the law of contagion rather than that of reason?

There are two aspects of spiritualism, one of which is entitled to the attention of scientific men and the other is not. When it is investigated by competent authorities, by men qualified for the task, it is proper to publish the results, and this we have done and are still doing. We have given more prominence in the pages of this periodical to psychical and psychological questions which involve and enwrap the phenomena of spiritualism — have published more papers bearing upon the philosophy of the subject—than any other popular magazine either in this country or abroad.

But there is another aspect of spiritualism which does not deserve the slightest regard from scientific men, and this is exactly the aspect which is most insisted upon by spiritualists. As its problems are usually presented, the man of science can not for a moment entertain them without committing intellectual suicide. Science postulates an inflexible order of nature as the foundation of all its work. It starts from this principle, and assumes it at every step, in every direction. That which makes science possible is the uniformities among the phenomena of the natural world. It is its sole business to trace out these uniformities in time and space, which form the essential fabric of nature's order. The man of science works them out and formulates them as laws. All scientific reasoning, all induction, deduction, generalization, comparison, classification, are based upon the regularity and constancy of natural operations. The first article of a scientific man's faith is that Nature never breaks her regularities, but holds true to an unalterable method of law. He knows that, if he comes upon what appear as breaks or suspensions of this order, it is he who is at fault, and that with further knowledge the apparent derangement will disappear.

Now, the spiritualist comes to him, challenging his first principles. He denies his order of nature as being unalterable, and says that he knows of that which is above nature, that is greater than nature, that interferes with it, and breaches all its vaunted stabilities with infinite ease. To this the man of science must logically reply: "I can not waste time in listening to you. I am limited to nature, you take your stand outside of it, and there is no common ground between us. You come to me denying that which I find demonstrated everywhere. Between your spiritualism and my naturalism there is a fundamental antagonism; your position is radically anti-scientific, and so let us keep clear of each other."

That such is the attitude of the honest spiritualist is undeniable. He approaches the man of science not as an inquirer —he does not know what inquiry is— but he comes with his mind made up, saturated with credulity, and full of tales about what is going on in transcendental spheres, psychic realms, and the supernatural world. Witness the harmonical philosophy of A. J. Davis, based upon intercourse with invisible beings; witness Mr. Kiddle's late book filled with alleged communications from the spirit-world. The whole mass of modern spiritualistic literature is made up of revelations claiming to be supernatural, and to constitute a modern miraculous dispensation. The assumption which underlies all this contradicts the truth which is at the foundation of all science. The believers in astonishing revelations ask for "investigation": their claims have been investigated for five hundred years, and all science is a report against them.

The state of mind here betrayed is simply lamentable; in respect of intelligence, it is not one whit in advance of the veriest superstitions of the middle ages. Spiritualists are men to

whom science *teaches* nothing; they reap its material advantages, but repudiate all its higher lessons. Practically they hold to the unalterable uniformities of nature. They ply the arts of industry, telegraph around the world, trust their lives on the flying train, and in a thousand exposures, practically certain that there will never be a hair's breadth of failure in the adamantine order of natural laws; and then they formulate a belief in ghosts who can kick holes through the rotten contexture of nature anywhere! Such beliefs are pernicious, not only because they are intrinsically false and absurd, but because they are in vicious hostility to science, and are a fatal obstruction to the advance of rational education. That science, as the most perfect form of knowledge, and therefore the true basis of education, has never had even decent consideration in the New York schools, is sufficiently well known; nor is the explanation far to seek, when their head turns out to be a spiritualist, and opens his book of revelations by the virtual announcement that he is miraculously called of God to arrest the course of modern scientific thought! If it be said that this is only the private eccentricity of a single person, the reply is, that we have yet to learn that it is not representative of the power that controls education in this city. The President of the Board of Education is reported to have said, when interviewed with reference to the removal of the Superintendent, "The strong feeling against him in the minds of the Commissioners who are opposed to Mr. Kiddle, arises not so much from any desire to interfere with his private opinions about spiritualism, as practically to show their disapprobation of the vapid trash to which he lends his sanction as communications from the spirits of the departed." From which we are to infer that, if the aforesaid "communications from the spirits of the departed" had been a little less vapid or trashy in their form, the board of officers who have in charge the formation of the minds of the young in this metropolis would have no objection to them. Our objection is not merely or mainly to the worthless character of Mr. Kiddle's book, but that it is an official insult to science; and we say that the mind which could dally with such vagaries is not fit to guide and shape the education of the young. We do not suppose that the New York Board of Education is constituted of men who either know or care much about science, or sound principles of education; but, as a new question is forced upon them which they can not escape, we respectfully commend to their consideration the instructive article of Professor Wundt.

HARRIS ON SOCIAL SCIENCE.

SUPERINTENDENT HARRIS, of St. Louis, has put forth an address on the "Method of Study in Social Science." The subject treated is important, and we took up his pamphlet hoping that, as an advanced educational leader, he had addressed himself to it with the practical view of determining the form and place it should take as a popular study in our American school system. We have long felt that it was desirable to have this done. Surely a State system of education, upon which millions are spent under the pretext that popular intelligence is necessary to the maintenance of free government, can not go on for ever ignoring all serious study of the natural laws of society, or the science of social relations. But we were disappointed. Mr. Harris gives us no help of the kind expected. On the contrary, his mode of dealing with the subject would seem to leave us no social science at all. He, however, speaks with an authority that is sure to give weight to his utterances, and it therefore becomes desirable to point out in what respect his views are misleading.

Mr. Harris begins his discourse with an excellent presentation of the method of the science of the present day. He recognizes that its tendency is to pass from the mere sensible properties of objects to their relations by saying: "No object can be understood by itself, and even the weather of to-day is found to be conditioned upon antecedent weather. . . . Science sees the acorn in the entire history of the life of the oak. It sees the oak in the entire history of all its species, in whatever climes they grow. . . . We must trace whatever we see through its antecedent forms, and learn its cycles of birth, growth, and decay. . . . We must learn to see each individual thing in the perspective of its history. . . . as a part of a process. . . . The ordinary habit of mind occupies itself with the objects of the senses, and does not seek their unity; . . . the scientific habit of mind chooses its object, and persistently follows its thread of existence through all its changes and relations."

All this is as true as it is well stated, and Mr. Harris, moreover, agrees that this method is coextensive with nature, and is therefore properly characterized as "natural science." But he knows a place where it does not apply and can not reach; a place so far set off from nature that it requires a new method of study, and gives rise to a new kind of science different from the common kind; and this, strange to say, is social science. He says: "Social science deals with man. Man has a natural being as a mere animal, as well as a spiritual being of intellect and will. . . . Man is not only an animal, having bodily wants of food, clothing, and shelter, but he is a spiritual being, existing in opposition to nature. . . . Man as a child or a savage is an incarnate contradiction; his real being is the opposite of his ideal being. His actual condition does not conform to his true nature. His true human nature is reason; his actual condition is irrational, for it is constrained from without, chained by brute necessity, and lashed by the scourges of appetite and passion. There is thus a paradoxical contrast between nature and human nature. . . . As man ascends out of nature in time and space into human nature, he ascends into a realm of his own creation. . . . The natural self must be abdicated in order that the personal self may be realized."

This theory of human nature is not new, but Mr. Harris certainly proposes to make a new use of it. For thousands of years it has been customary to divide man into two natures: a low, gross, corrupt, perishable, animal nature to be reprobated and renounced; and a high, pure, exalted, immortal nature, chained to the brutal part, and at war with it through all the course of our earthly life. This view has long been useful to theologians and moralists, but Mr. Harris is the first to reconstruct modern science on this basis. He would hand over the bestial, vulgar, and vilified part of humanity to "natural science"; and he would erect the upper and nobler portion into a new kind of science by a new method; and, as it is the more exalted portion of man which he "realizes in institutions," the new method becomes that of social science.

Yet, with reference to science, lower and higher are all one, and man is a unity. His higher nature is phenomenal, and in its constitution, mode of acting, as well as in its productions, it is not chaotic, but orderly, and is thus open to investigation like all the other parts of nature. That there is a profound difference between the corporeal and the psychical parts of man involves no such consequences as are here assumed. However deep may be the diversities among the objects of study in nature, the method of science in dealing with them is the same; because science, being the most valid knowing, depends upon the laws of knowing, and not upon the differences among the objects in-

vestigated. A hundred years ago it was objected that the legitimate methods of science can not be applied to the study of living things. Science had been created by investigations in the inorganic sphere, and true science was held to be limited to that sphere. When the inquirer left his gases, ores, and metals, to cross the boundary and begin a search into the nature of things that live, he was told that life is a mysterious realm where vitality suspends inorganic laws, and holds sway above nature and in opposition to it. Yet the province was long since conquered, and annexed to the domain of "natural science." The question in any case is simply this: Are we dealing with phenomena that may be observed, compared, analyzed, generalized, and reduced to a body of principles?

Mr. Harris discredits the method of natural science in its application to society, as follows: "From the fact that all merely natural beings—whether mineral, plant, or animal—never rise to the form of self-knowing and self-realizing, it follows that the application of scientific method to the explanation of human institutions in the ordinary form is not valid. In nature we explain the present by the past. If we attempt to explain the institutions of the family, society, and the state, by the rudimentary forms found in the childhood of the race, or, still worse, by the habits of the higher animals—as the ape tribe, for example—we shall invert the true method for social science. Since all of man's institutions arise as forms of combination, which he has made in order to realize an ideal, it follows that the first ones, historically, are so rudimentary as scarcely to indicate their object, while the later and latest ones contain the explanation of themselves and of their predecessors."

We gather from this that Mr. Harris's "Method of Study in Social Science" is to ignore the historical aspect of the subject, and begin with the study of the most complex institutions. Then why not adopt the same method in the study of other subjects? Fancy him addressing a mathematical teacher as follows: "Since the advanced rules of arithmetic arise as forms of combination, which the mathematician has made in order to realize an ideal, it follows that the first rules are so rudimentary as scarcely to indicate their object, while the later and latest contain the explanation of themselves and of their predecessors; therefore, begin your class and keep it occupied with problems in the last portions of the text-book." On the contrary, it is the law of method in all study to proceed from the simple to the complex, from the lower to the higher, and to explain the more developed by the less developed. Mr. Harris's "method" would put an end to all embryological study; for, if society is not to be studied historically because its first forms "are so rudimentary as scarcely to indicate their object," is not that equally true of *all* rudimentary forms? His method is false everywhere. Adult institutions, like adult animals, can only be explained by beginning with their germs and tracing the course of organization.

But Mr. Harris does not leave us to infer the character of his new social science; he gives the formula of its method in explicit terms, as follows: "For the study of society, then, one must seek his principle of explanation not in the child or the savage, but in the ideals of the prophets of humanity. We are to understand Greek life through a study of Homer and Plato; the middle ages through Dante and Thomas Aquinas; modern times through Shakespeare and Goethe."

So we are to omit the child and the savage in the study of society; and Mr. Harris adds, "Above all, we must not make the mistake of studying man as a simple individual." But what will then be left to study? We have always

supposed that society was made up of children, savages, and individuals, and that according to the natures and attributes of these units would be the character of the societies formed of them. But this it seems is a case in which the properties of a whole are not dependent upon the properties of its parts. Verily it would be an extraordinary "social science" that should arise by omitting the study of man as an individual, and interpreting society by the ideals of its literary prophets.

LITERARY NOTICES.

SPENCER'S SYNTHETIC PHILOSOPHY:

The Data of Ethics. By Herbert Spencer. New York: D. Appleton & Co. Pp. 288. Price, $1.50.

This little book is the first part of the treatise on morality that will close Spencer's "System of Philosophy." As explained in his preface, it is the result of long preparation, and is published not in the order he at first designed. He says: "I have been led thus to deviate from the order originally set down by the fear that persistence in conforming to it might result in leaving the final work of the series unexecuted. Hints repeated of late years with increasing frequency and distinctness have shown me that health may permanently fail even if life does not end before I reach the last part of the task I have marked out for myself. This last part of the task it is to which I regard all of the preceding parts as subsidiary. Written as far back as 1842, my first essay, consisting of letters on 'The Proper Sphere of Government,' vaguely indicated what I conceive to be certain general principles of right and wrong in political conduct; and, from that time onward, my ultimate purpose, lying behind all proximate purposes, has been that of finding for the principles of right and wrong in conduct at large a scientific basis. To leave this purpose unfulfilled, after making so extensive a preparation for fulfilling it, would be a failure, the probability of which I do not like to contemplate; and I am anxious to preclude it, if not wholly, still partially. Hence the step I now take. Though this first division of the work, terminating the 'Synthetic Philosophy,' can not of course contain the specific conclusions to be set forth in the entire work, yet it implies them in such wise that definitely to formulate them requires nothing beyond logical deduction."

But few will deny the importance of the work which Mr. Spencer has so long had in view for, of all fields of thought, the ethical is in the most chaotic condition. Some find the grounds of morality in the Ten Commandments, and others in the rules of the New Testament. The fear of hell is appealed to as a motive to right conduct, and the divine intuitions of conscience are claimed as guides to duty. As faith in the supernatural declines, many are left without any authoritative moral guidance, while some fall back on a prudential utility, and others upon the interdicts of public law. These theoretical discords are accompanied by varying standards of right and wrong in different states and periods of society, while everywhere are seen the most glaring discrepancies between professed moral precepts and actual moral practice.

Meantime, in other fields of thought, science is the great reconciler of conflicting opinions. By the establishment of comprehensive principles that command universal assent, it is constantly bringing men into better agreement; and it has thus become an authority that is enforcing the submission of the human mind with steadily increasing power. Moral phenomena, like mental and physical phenomena, are obedient to principles of order, and are thus amenable to scientific method; science, therefore, must traverse the ethical field in its legitimate progress; and there is no reason to doubt that it will perform the same benign office of illumination and guidance here, that it has performed in the other great spheres of its application.

But, if this is true, it may well be asked why science has not long since accomplished so desirable a work. It is because centuries of preparation were required to develop the preliminary sciences and perfect the method of inquiry; and because it is a task of such difficulty that but few men could be expected to combine the scientific qualifications, the patient, untiring industry,

and the sustained interest in the subject necessary to deal with it adequately and successfully. Mr. Spencer entered upon this line of study in his youth, and has devoted his life to it. He has explored and reorganized several of the great divisions of science with reference to their ultimate bearings upon the problem of scientific morality; and he is undoubtedly the first to work out the philosophical relations of the sciences to a new system of ethical doctrine.

In this brief notice of a work that requires to be thoughtfully read, we can no more than open the subject; and this can best be done by anticipating certain questions that will arise at the outset in the minds of many readers. It will be said, in the first place: "We know something about morality, having often heard it expounded and applied. It lays down the regulations of behavior. Government enforces it by its laws, and society rests upon it. It seems a very practical, common-sense thing that everybody can understand, as we must all obey its injunctions; but what on earth do you mean by 'scientific morality'?"

The reply is, that "scientific morality" is that kind of morality which can give valid reasons for its requirements. Science stands in just the same relations to morality that it does to every other kind of human activity—it explains it. Dyeing was long a successful practical art; but it consisted in following a set of blind rules, and its operations were imperfect. Science explained it, and gave principles instead of rules, which gave the reason of many failures, and led to greatly improved practice. In like manner morality follows blind and arbitrary rules, and its practice is notoriously imperfect. Science will substitute intelligible principles for these rules which will account for numerous failures, and lead to better practice.

The question may be answered in another way. It is the object of Mr. Spencer's present work to lay the foundations of an ethical system that shall have the validity and authority of scientific truth, by showing that the principles of right and wrong in human conduct are grounded in the constitution of nature. It is obvious that, until the order and course of nature were understood, such an inquiry must have been unsuccessful and impossible. Science alone explains that order, and therefore furnishes the facts and truths that are necessary to the investigation. But if science, by this elucidation, has supplied the data from which the principles of morality can be derived, and its practice consequently perfected, the working out of the subject must give us a "scientific morality."

In the next place it will be asked: "What has morality to do with evolution? As the best ethical maxims go back to a high antiquity, and as, according to Mr. Buckle, while the intellect is progressive, morals are stationary, what possible relation can the evolution theory have to ethics?" Mr. Spencer furnishes the answer to this question at the very opening of his book, and in a way which shows that, if evolution be true at all, it has everything to do with morality.

His first chapter is on "Conduct in general," and he begins by illustrating the truth that no correct idea can be formed of a part without a knowledge of the whole to which it belongs. A detached arm could not be understood by a being ignorant of the human body; the moon's movements can not be interpreted, except in connection with the movements of the solar system; a fragment of a sentence is unintelligible if separated from the remainder.

Morality deals with a certain kind of human conduct, but this implies that there is another kind, of which moral conduct is but a part. Again, the term "human conduct" implies that there is a conduct manifested by creatures other than human, so that human conduct becomes a part of a still larger whole. Conduct is defined as actions adjusted to ends, and is displayed in ever-varying degrees of simplicity and complication throughout the entire scale of animate being. Animals low in type, in seeking food, adjust actions to ends, and, as we rise through the series, such adjusted actions become more varied, combined, and perfect, until man is reached, when the adjustments become far more complex and involved, and the ends attained more numerous, varied, and remote. Mr. Spencer says: "Complete comprehension of conduct is not to be obtained by contemplating the conduct of human beings only: we have to regard this as a part of universal conduct—conduct as exhibited by all living creatures. Just as, fully to understand the part of con-

duct which ethics deals with, we must study human conduct as a whole, so, fully to understand human conduct as a whole, we must study it as a part of that larger whole constituted by the conduct of animate beings in general. Nor is even this whole conceived with the needful fullness so long as we think only of the conduct at present displayed around us. We have to regard the conduct now shown us by creatures of all orders as an outcome of the conduct which has brought life of every kind to its present height, and this is tantamount to saying that our preparatory step must be to study the evolution of conduct."

The second chapter is devoted to "The Evolution of Conduct," and its import may be gathered from the concluding passage: "Guided by the truth that as the conduct with which ethics deals is part of conduct at large, conduct at large must be generally understood before this part can be specially understood; and guided by the further truth that to understand conduct at large we must understand the evolution of conduct, we have been led to see that ethics has for its subject-matter that form which universal conduct assumes during the last stages of its evolution. We have also concluded that these last stages in the evolution of conduct are those displayed by the highest type of being, when he is forced by increase of numbers to live more and more in presence of his fellows. And there has followed the corollary that conduct gains ethical sanction in proportion as the activities becoming less and less militant and more and more industrial are such as do not necessitate mutual injury or hindrance, but consist with and are furthered by coöperation and mutual aid."

The position here assumed at the outset that morality is a product of evolution is illustrated and confirmed with convincing force throughout the work. Why the moral restraints of conduct are the latest evolved appears by considering the nature of the different kinds of control to which men have been subjected during the unfolding of society. As fully explained in the "Sociology," society begins only in subordination to violent external restraints. The rule of the despotic chief is the germ which develops into the political control of human conduct. The primitive fear of the ghost of the dead chief develops into the superstitious dread of unseen forms, and ultimately becomes that powerful religious control which is so potent in influencing the actions of men. A later developed but definite and powerful form of restraint upon conduct is the influence of public opinion, or the force of social reprobation. The results of these forms of external coercion are so simple, direct, and easily conceived that they are well fitted to act upon undeveloped natures, and they come into play first in the order of social progress.

The moral motive to conduct differs from the preceding by recognizing the results that actions naturally produce. As Mr. Spencer remarks: "We are now prepared to see that the restraints properly distinguished as moral are unlike these restraints out of which they evolve, and with which they are long confounded, in this—they refer not to the extrinsic effects of actions but to their intrinsic effects. The truly moral deterrent from murder is not constituted by a representation of hanging as a consequence, or by a representation of tortures in hell as a consequence, or by a representation of the horror and hatred excited in fellow men; but by a representation of the necessary natural results—the infliction of death-agony on the victim, the destruction of all his possibilities of happiness, the entailed sufferings to his belongings. Neither the thought of imprisonment, nor of divine anger, nor of social disgrace, is that which constitutes the moral check on theft; but the thought of injury to the person robbed, joined with a vague consciousness of the general evils caused by disregard of proprietary rights.

"And now we see why the moral feelings and correlative restraints have arisen later than the feelings and restraints that originate from political, religious, and social authorities; and have so slowly, and even yet so incompletely, disentangled themselves. For only by these lower feelings and restraints could be maintained the conditions under which the higher feelings and restraints evolve. It is thus alike with the self-regarding feelings and with the other-regarding feelings. The pains which improvidence will bring, and the pleasures to be gained by storing up things for future use and by laboring to get such things, can be habitually contrasted in thought, only

as fast as settled social arrangements make accumulation possible; and, that there may arise such settled arrangements, fear of the seen ruler, of the unseen ruler, and of public opinion, must come into play. Only after political, religious, and social restraints have produced a stable community, can there be sufficient experience of the pains, positive and negative, sensational and emotional, which crimes of aggression cause, as to generate that moral aversion to them constituted by consciousness of their intrinsically evil results. And more manifest still is it that such a moral sentiment as that of abstract equity, which is offended not only by material injuries done to men, but also by political arrangements that place them at a disadvantage, can evolve only after the social stage reached gives familiar experience both of the pains flowing directly from injustices and also of those flowing indirectly from the class-privileges which make injustices easy."

We are here brought to another exemplification of the method of scientific morality, as influenced by the doctrine of evolution. If the higher control of conduct is derived from a knowledge of its consequences, then the supreme problem of morals is the study of causation in human actions. Everything here turns on the relation of cause and effect; and Mr. Spencer shows conclusively that the development of the idea of causation is one of the latest results of man's intellectual progress. The conception of causation as necessary and universal has even yet been reached only by a small circle of strict scientific thinkers. This is the radical defect of the earlier and current moral systems. In his chapter on "The Ways of judging Conduct," Mr. Spencer proves that the religious, the intuitional, the political, and the utilitarian schools are here alike deficient: "They do not erect into a method the ascertaining of necessary relations between causes and effects, and deducing rules of conduct from formulated statements of them." Evolution, on the other hand, implying the persistence of forces and the continuity of effects, when applied to ethics must give us a new method of "scientific morality."

We have here touched only upon incidental points in Spencer's work; the fundamental principle of his system could have no justice done to it in such a notice. This idea is that pleasure and pain, in some form immediate or remote, are at the bottom of all good and bad, all right and wrong. The doctrine is involved in the statement that "there exists a primordial connection between pleasure-giving acts and continuance or increase of life, and, by implication, between pain-giving acts and decrease or loss of life"; or that it is "no more possible to frame ethical conceptions from which the consciousness of pleasure, of some kind, at some time, to some being, is absent, than it is possible to frame the conception of an object from which the consciousness of space is absent. And now we see that this necessity of thought originates in the very nature of sentient existence. Sentient existence can evolve only on condition that pleasure-giving acts are life-sustaining acts."

We think that the verdict on this book of all candid readers will be that it accomplishes what it professes to accomplish—it finds for the principles of right and wrong in conduct a scientific basis; and, if this be true, it is needless to say that its effect will be to give a new impulse and a new direction to ethical studies.

The Sportsman's Gazetteer and General Guide. The Game Animals, Birds, and Fishes of North America; their Habits and Various Methods of Capture. Copious Instructions in Shooting, Fishing, Taxidermy, Woodcraft, etc. Together with a Glossary, and a Directory to the Principal Game Resorts of the Country. Illustrated with Maps. By Charles Hallock, Editor of "Forest and Stream," etc. Fifth edition. New York: Forest and Stream Publishing Co. 1879. Pp. 920. Price, $3.

The scope and purpose of this volume are so fully set forth in the title that there is no need of further particularizing its contents. The "Gazetteer" is an indispensable part of the outfit of hunters and fishers throughout the United States and the Canadas. In this fifth edition nothing appears to have been omitted which should properly have a place in such a manual. The Glossary is one of the new features introduced in this edition, and it adds greatly to the value of the work. Here are to be found definitions of common words in local use throughout North America. Strangers are

often sorely puzzled by these localisms, and Mr. Hallock does well in providing them with an interpreter.

THE JOURNAL OF PHYSIOLOGY. Edited by Dr. MICHAEL FOSTER. Vol. I., Nos. I. to VI., 496 pages; Vol. II., No. I., 90 pages. New York: Macmillan & Co.

THE first volume of this most valuable periodical is now completed, and the first part of the second volume is also published. We again call the attention of our scientific and medical readers to its merits, and also urge for it the patronage of liberal-minded men whether professional or not. To those interested in its discussions we need not say that it is invaluable, as it represents the progress of research in physiological science, and gives the latest trustworthy results on a wide range of subjects. It is edited by an able corps of gentlemen, who, of course, contribute their services freely, and with no thought of remuneration, from simple love of the promotion of knowledge. And who is not interested in the advancement of this branch of science. "The Journal of Physiology" ought to be taken in every library, college, and high-school, if for no other reason than because it is a public duty to sustain it. It is a scandal to civilization that, when wealth is squandered so profusely on absolutely worthless things, men of science, living on stipends, and giving their very life-blood to laborious researches, should have to retrench their vital necessities to pay for the publication of their original work, which is of untold value to the community.

People generally have but a very imperfect idea of the activity of scientific inquiry at the present time, because it is a world by itself, with which our literary, political, and religious classes have very little concern or sympathy. The physiological division of science furnishes a very good illustration of the extent of this vigorous original work. The editors of "The Journal of Physiology" have issued a supplement to Vol. I. containing a list of titles of works and papers of physiological interest published in 1878. We subjoin the classified headings of this list, which will convey an idea of the scope of these investigations, and give the number of works that appeared last year in each division:

	Works.
1. Text-books, Methods, etc.	41
2. General Physiology, General Properties of Protoplasm and Cells	39
3. General Chemistry of Tissues and of Animal and Vegetable Substances	85
4. General Physics	22
5. Structure and Properties of Cartilage, Bone, and Connective Tissues	19
6. Blood, Structure and General Features.	20
7. Circulation	100
8. Lymphatic System	6
9. Alimentary Canal, Digestion, etc.	56
10. Respiration	31
11. Perspiration, etc	20
12. Urine	44
13. General Metabolism of Body	44
14. Animal Heat	8
15. Structure of Contractile and Nervous Tissues	28
16. General Properties of Contractile Tissues, Muscle, and Nerve	41
17. General Nervous System	99
18. Eye, Vision	86
19. Ear, Hearing	16
20. Skin, Touch	14
21. Speech	13
22. Locomotion	2
23. Reproduction	29
24. Action of Drugs	83
25. Ferments, etc.	64
Total	1,010

SOUVENIRS OF MADAME VIGÉE LE BRUN. With a Steel Portrait from an Original Painting by the Author. New York: R. Worthington. Pp. 398. Price, $1.75.

MADAME LE BRUN was born in Paris in 1755, and died in 1842, and during the greater part of that time was employed in painting the portraits of the reigning families of Europe. She was the contemporary and friend of Joseph Vernet, of Benjamin West, and of Sir Joshua Reynolds, all of whom bore testimony to her rare ability as an artist. It is said that, on the opening in London of her portrait of Calonne, a bystander remarked: "It ought to be good, for Madame Le Brun received £3,200 for it"; when Sir Joshua replied, "If they gave me £4,000 for it, I could not have done it as well." Being not only a great favorite at the different European courts, but her *salon* forming a rallying-point for the most distinguished people in fashion, in literature, and in art, she had at her command a surprising wealth of material, and these reminiscences form a curious though unconscious history of the morals as well as the manners of that interesting period.

Take for instance her *naïve* accounts of her intercourse with the Duchess du Barry, Catharine II., and Lady Hamilton. The most interesting of her souvenirs are those connected with the reigns of Louis XVI. of France, of Catharine II. and Paul I. of Russia, of Queen Caroline of Naples, and of George III. of England, and the most distinguished of their subjects in every department. D'Alembert, La Harpe, Abbé Sieyès, Talleyrand, Prince Kaunitz, Poniatowski, Potemkin, Angelica Kauffmann, Catalini, Mademoiselle Mars, Madame Récamier, the Duchess of Devonshire, Herschel, Sir Francis Burdett, etc., furnish abundant subject-matter for her lively and gossiping details.

Outlines of Field Geology. By Archibald Geikie, F. R. S., Director of the Geological Survey of Scotland. New York: Macmillan & Co. Pp. 222. Price, $1.

Professor Geikie's lectures upon this subject, delivered at the South Kensington Museum in 1876, and subsequently printed in a pamphlet form, were noticed at the time of their appearance. He dwelt upon the methods of observation requisite in ordinary field geology, with practical directions for noting and recording the facts observed. It met with a cordial reception, and a large impression was disposed of. The author has now rewritten and enlarged the work, dropping the lecture form, increasing the illustrations, and giving it a shape that will make it a standard guide for geological students. The book assumes that the young geologist has read some good text-book and got a general knowledge of the elementary principles of the subject, and then wishes to become acquainted with the science as a reality. It is for the use of those who, having a book-knowledge of geology, "find themselves helpless when they try to interpret the facts which they meet with in the field. The practical knowledge of which they feel the want is not to be gained from books. It must be sought in quarries and ravines, by hillside and seashore. But hints regarding what should be looked for and how to set about the search may not be without some usefulness; and these it is the object of the following pages to give."

Manuals for Teachers. No. 1. The Cultivation of the Senses. Philadelphia: Eldridge & Brother. Pp. 96. Price, 50 cents.

It is announced that this series will contain four more works—"The Cultivation of the Memory," "On the Use of Words," "On Discipline," and "On Class-Teaching." The publishers say: "These manuals were originally published in England, having been prepared, at the request of the Literature Committee of the National Educational Society, by men distinguished at their several universities, and possessed of large experience as teachers. They have been carefully revised and adapted to the wants of American teachers, and it is hoped will prove a valuable addition to the literature of the art and science of teaching." We suspect that these distinguished university men are myths; at any rate the present volume betrays no such distinguished origin. It is a very good little compilation from various authorities; but how comes it that, while Spencer, Taine, and Darwin are quoted, no mention is anywhere made of Miss Youmans's essay "On the Cultivation of the Observing Powers of Children," which is freely copied, and whole pages taken bodily without any recognition? The publishers bring out the series in a very neat and substantial form.

Eleventh Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology. Vol. II., No. 2. Cambridge: The Trustees. 1878. Pp. 286.

During the past year the Trustees of the Peabody Museum took possession of the new building specially erected at Cambridge for the purpose of holding their ethnological and archæological collections. The report contains, besides a description of this building, a history of the Peabody Museum, by the Hon. Robert C. Winthrop, the report of the Curator, and a number of contributions on archæological subjects, viz.: Dr. Abbott's second report on implements found in the glacial drift of New Jersey; remarks on the method of manufacture of several articles by the former Indians of southern California, by P. Schumacher; on cave-dwellings in Utah, by E. Palmer; on the manufacture of soapstone pots by the Indians of New England, by F. W. Putnam; on a collection

from an ancient cemetery in southern Peru, by J. H. Blake; on archæological explorations in Tennessee, by F. W. Putnam; on crania from the stone graves of Tennessee, by L. Carr; and on the tenure of land among the ancient Mexicans, by Ad. F. Bandelier.

First Annual Report of the United States Entomological Commission. Washington: Government Printing-Office. 1878. Pp. 800, with Maps and Plates.

We have here in full detail the first year's labors of the United States Entomological Commission, appointed by Congress to study the best methods of preventing the ravages of the Rocky Mountain locust. The habits of the insect, its geographical distribution, and many other points in its natural history, have been pretty satisfactorily determined by the Commission; and, if the Commission has not succeeded in discovering *the* method of getting rid of the pest, it has at least indicated many ways of lessening its violence, and of partially staying its advance.

Seventh Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois. By C. Thomas, Ph. D., State Entomologist. Springfield, Illinois: D. W. Lusk print. Pp. 290.

The most elaborate paper in this report is one entitled "Notes on Corn Insects, or Insects injurious to Indian Corn." The author has been investigating this special subject for a long time, and his results, as here stated, are eminently worthy of the attention of the farmer. These "Notes" occupy the first one hundred pages of the report; the remainder is devoted to miscellaneous notes and observations on different species of noxious and beneficial insects.

Progressive Japan: A Study of the Political and Social Needs of the Empire. By General Le Gendre. San Francisco: A. L. Bancroft & Co. 1878. Pp. 380.

In this study of the social and political needs of Japan, General Le Gendre has sought mainly from the history of the Japanese people the aid which others might perhaps have preferred to ask solely from abstract Western sciences. "It is," he writes, "by interpreting a people's traditions, by carefully listening to the mysterious teachings of the wise men who, in remote ages, guided its infancy, that one is apt to discover the early promise of its future." Therefore, in the reconstruction of the political state of Japan, care must be taken not to do violence to the national genius by prematurely introducing Western institutions. The author treats at great length of "Reconstruction," and points out the direction which, in his opinion, it must take in order to produce the largest measure of good for the Japanese people.

PUBLICATIONS RECEIVED.

The Historical Poetry of the Ancient Hebrews, translated and critically examined. By Michael Heilprin. Vol. I. New York: D. Appleton & Co. 1879. Pp. 243. $2.

Report of the Chief Signal Officer to the Secretary of War, 1878. Washington: Government Printing-Office. Pp. 680, with Plates and Charts.

The Silk Goods of America. By William C. Wyckoff. New York: D. Van Nostrand. Pp. 120.

Laboratory-Teaching, or Progressive Exercises in Practical Chemistry. By. C. L. Bloxam. Philadelphia: Lindsay & Blakiston. 1879. Pp. 261. $1.75.

An Introduction to Commercial Organic Analysis. By A. H. Allen, F. C. S. Vol. I. Same publishers. Pp. 374. $3.50.

Geological Survey of Indiana, 1878. By E. T. Cox, State Geologist. Indianapolis: "Journal" print. Pp. 541, with Maps.

Report of the Chief Engineer of the Philadelphia Water Department, 1878. Philadelphia: Markley & Son print. 1879. Pp. 111.

Tovey's Brewers' Directory for 1879. New York: A. E. Tovey, 24 Park Place. Pp. 115.

Sketch of Dickinson College. By C. F. Hines, Ph. D. Illustrated. Harrisburg: L. S. Hart. 1879. Pp. 155.

Around the World with General Grant. By J. R. Young. Published in 20 Parts, at 50 cents each. Illustrated. New York: American News Company,

Chemistry, Theoretical, Practical, and Analytical. Parts 36 to 40. 50 cents each. Philadelphia: J. B. Lippincott & Co.

Twelfth Annual Meeting of the Free Religious Association, 1879. Boston: The Association. Pp. 80.

Dictionary of Music and Musicians. Part 7. New York: Macmillan & Co. $1.25.

Brentano's Aquatic Monthly and Sporting Gazetteer. New York: Brentano. Monthly. $4 per year.

Future Development of the New York State Library. Albany: Van Benthuysen & Sons. Pp. 48.

Lake Chautauqua Illustrated. Buffalo: Peter Paul & Bro. Pp. 60.

The Chaco Cranium. By W. J. Hoffman, M. D. Washington: Government Printing-Office. Pp. 25, with Plates.

Explorations and Surveys in the Department of the Missouri. By E. H. Ruffner, Engineer

Corps U. S. A. Washington: Government Printing-Office. 1878. Pp. 115.

On a New Base. By E. F. Smith. From "American Chemical Journal." Pp. 8.

The Tornado of April 14, 1879, By J. L. R. Wadsworth, M. D., and F. E. Nipher. From "Transactions St. Louis Academy of Science."

Thevetia Iccotli and its Glucoside. By D. Cerna, M. D. From "Philadelphia Medical Times." Pp. 6.

Annual Announcement of the Stevens Institute of Technology. Pp. 104.

Report of the Work of the Agricultural Experiment Station at Middletown, Conn. Hartford: Case, Lockwood & Brainard Company print. Pp. 174.

On a Foundation for a Religion. Boston: G. H. Ellis print. Pp. 48.

Geological Formations crossed by the Syracuse and Chenango Valley Railroad. By L. M. Underwood. Syracuse: "Standard" print. Pp. 18.

Wandering Cainidæ, or the Ancient Nomads. By M. Kempe, M. D. Louisville, Ky.: Morton & Co. print. Pp. 41. 25 cents.

POPULAR MISCELLANY.

American and European Archæology.—A marked difference is observable between Europe and America with respect to the order of succession of the different prehistoric human "periods" to one another. In fact the succession is in the one exactly the reverse of what it is in the other. This difference is clearly expressed by the Rev. Stephen D. Peet in an article on "The Archæology of Europe and America." "In Europe," he says, "the cave-hunter, who used bone implements, first departed; the fisherman of the kitchen-midden next passed away; the builder of the earth-mounds followed with his rude weapons, and the inhabitants of the palafitte next disappeared; and last of all the Etruscan, the builder of the rude stone monuments. Thus Esquimau, Basque Briton, Belgian, Celt, Saxon and Etruscan [?], are the successors to one another, while on this continent Quiches, Toltec, Aztec, Mound-builders, Red Indians, and Esquimaux are the silent throng who have reversed the column of departure. The Esquimau was ruder than the Basque, and the Basque than the Briton, and so the order of departure gave place to a higher culture. In America the most civilized was the soonest removed, and the rudest remained the longest. The ancient city was deserted, but the pueblo remained; the pueblo itself changed inhabitants, but the Mound-builder remained; the Mound-builder was driven away, but the Red Indian continued; the Red Indian has disappeared, but the Esquimau abides. The palaces of Palenque and Uxmal and the seven cities of Cibola are monuments of a civilization more ancient than the Mound-builders. The mounds of the Mississippi Valley were doubtless erected by a more ancient race than the people who occupied at the time of their discovery. The Red Indians held an unbounded dominion more ancient than the villages which they inhabited, and the Esquimaux may possibly have once covered the whole land where all of these tribes so lately roamed, but the last survivor of all is now the rudest and wildest."

Division and Distribution of the Electric Light.—A method of *dividing electric light* (not the electric current, but the light itself) has been devised by two engineers of San Francisco, E. J. Molera and J. C. Cebrian. The scheme looks plausible, but the public can afford to wait till it has been put to a practical test. We give the inventors' own description of the *modus operandi* of their system: "We take," they say, "the most powerful source of light attainable, and place it in a closed chamber (*the chamber of light*). Every wall of this box is a condensing lens, which will shape the light into a beam of parallel rays. In this way we reduce our source of light to several beams of parallel rays. If we intercept one of these beams of parallel rays of light by a reflector, the light will be bent or reflected according to the position of the reflector; and it may thus be sent into any desired direction, horizontal, vertical, or any way inclined. When the reflector intersects the whole beam of light, this latter one will be bent totally; if only one fraction of the sectional area of said beam is intersected, then the corresponding fractional part of the beam will be bent, leaving the other fraction thereof to follow its former direction. Therefore, if one of said beams of light is intersected at different points of its length, by different reflectors, intersecting different fractional parts of its section, said beam will be divided into a great number of secondary beams, going in any desired direction, and if these secondary beams are treated in the same way, the main beam can be di-

vided, subdivided, conveyed, and distributed to any number of distant places. If we inclose the main beam in a tube or pipe, and every secondary beam in smaller tubes, branching out from the larger one adjoining it, and we keep the above said reflectors at the elbows and intersections, or T-pieces, formed by all these tubes, we obtain a net or system of pipes or tubes similar to those used in the distribution of gas and water.

"Such is our system: in front of every side or face of our *chamber of light*, we place a box or pipe inclosing the main beams of light; these pipes are laid along the streets; at every side street a smaller pipe will branch out from the main one; at their junction we will place a reflector which will divert into the side street the desired percentage of light. And thus we can provide every street of a city with one or more pipes carrying a known amount of light. Then, from said street-pipes, service-pipes will be run into every lamp-post and every building, and at the intersection of the latter pipes with the street main we will insert proper reflectors, the size of which will determine the amount of light supplied by every service pipe. In the same way that at present the gas-burners of all the rooms in a house are in direct successive communication with the gas-meter or service-pipe, for said house, through a net of pipes laid along ceilings and walls; similarly in our system, a net of properly branched-out pipes will put in communication every room of a building with the above-mentioned service-pipe; only that we will place at every junction, occurring in said net of pipes, a proper reflector, which will determine the amount of light carried by the corresponding pipe. Thus, the light may come into the rooms through the ceiling or through the walls, every room having as many outlets of light as desired. But the light will enter in a beam of parallel rays; therefore, in order to properly shape it for use, we will place at every outlet of light a *diffusing lens*, called a *secondary lens*, which will send the light around in any predetermined shape; thus completing the system of division and distribution of light from a single station to any or all the rooms in a city, and with any desired intensity."

Primitive Innocence.—In a letter read at a meeting of the Academy of Natural Science, of Philadelphia, Dr. Charles A. Siegfried, U. S. N., writes as follows: "We visited an island called Botel Tobago while surveying a rock, eighty miles east of South Cape, off Formosa. We found a race of aborigines, probably from Malay stock. They knew nothing of money, rum, or tobacco. They gave us goats and pigs for tin pots and brass buttons, and would hang around us all day in their canoes, waiting for a chance to dive for something thrown overboard. They wore clouts only; ate taro and yams mainly, though they have pigs, goats, chickens, and fish, and cocoanuts also. Snakes abound, of the boa variety, I judge. Their thatch houses are low, with much overhang of the roof, surrounded by stone walls, strongly made of laid stone, to protect them from monsoons. Their paddy-fields contain immense quantities of taro—*Colocasia aroidea*, my botany says. They are peaceful and timid, do not mark the body or deform the face or teeth, and seem happy enough in their condition. I found them fairly healthy. They had axes, spears, and knives, but all of common iron, the axe being made by imbedding the handle, instead of the handle piercing the iron, as with us. Their canoes are beautiful, made without nails, and are ornamented usually with geometrical lines. The hair is worn naturally, the men partly clipping theirs. I saw no valuable metal. They wore the beards of goats, with small shells, as neck ornaments."

New and Interesting Fossils.—While examining the "Atlantosaurus beds" of the Rocky Mountains, Professor Marsh discovered several interesting fossils, among them the lower jaw of a small mammal—a diminutive marsupial. This is the second mammal known from the Jurassic in this country. The specimen, which is from the left side, has the larger part of the ramus preserved, with a number of perfect teeth in position. Most of the symphysial portion is lost, and the posterior part is missing, or only faintly indicated. The jaw was remarkably long and slender. The horizontal portion is of nearly equal depth throughout, and the lower margin nearly

straight. The remarkable feature in this jaw is the series of premolar and molar teeth. These were very numerous, apparently as many as twelve in all, possibly more. In comparing this fossil with the forms already known, it is seen to differ widely from any living type. Its nearest affinities are with the genus *Stylodon* of Owen, and in many respects the correspondence is close.

In the "American Journal of Science," for September, Professor Marsh describes two lower jaws belonging to animals apparently of the same genus (*Dryolestes*) as the first American Jurassic mammal; these remains came from the same locality and horizon as the preceding. These new specimens furnish important characters to distinguish the genus. In one of them the angle of the lower jaw is strongly inflected, thus indicating its marsupial nature. The other proves that the genus is quite distinct from *Didelphys*, as there were at least four premolars. This specimen differs from the jaws of *Dryolestes priscus* (the first Jurassic mammal found in this country) in being more slender, less curved, and less compressed. Professor Marsh gave to the species the name *Dryolestes vorax.* The animal appears to have been smaller than *D. priscus.*

Classification of Words by Ideas.—At the recent Philological Convention at Newport, Mr. Stephen Pearl Andrews read an interesting paper proposing some further development of views previously suggested regarding the classification of terms by the ideas they represent, and he showed that the process already begun is capable of being carried to a far greater degree of simplification than has yet been reached. Mr. Andrews's paper was to the effect that there are two possible ways of pursuing the study of words, one of which only has heretofore been brought into use, and the adoption of the other one of which will constitute a new method and a new era in philology. These two ways are—1. To study the word, as a bundle of sounds, the body of the word first, and in the main, and the idea or meaning of the word in a secondary and incidental manner merely; and, 2. To study the idea embodied in the word, as the main thing, making the phonetic structure of the word secondary and accessory to the word. The first of these methods Mr. Andrews calls historical or physical, and the second ideological or psychical. The historical method is the current and triumphant method, initiated by Jacob Grimm, and now completed, in a sense, by August Fick, in the supplement to his dictionary of the Indo-Germanic language, where he sums up the root-words as a mere handful (50 to 500), from which all the words (virtually) ever spoken in southern and western Asia, and in Europe, are derived. This historical method Mr. Andrews also calls, therefore, the German method, and he thinks it has now achieved nearly all that it is able to do.

The ideological method has hardly yet been begun, and remains now to be elaborated. It was, however, unconsciously initiated by Noah Webster, in the introduction to his dictionary, while he was working for a quite different purpose, and may therefore be called, for easy distinction, the American method. As Fick reduces all the words we use to a mere handful, so Webster, on the other hand, reduces the *meanings* of all these words to a group of thirty-four leading ideas, a less number than that of Fick's root-words. Both the German and the American method are, therefore, traveling on the road to lingual unification, or, what is the same thing, to the reduction of language to an ultimate simplification. On the side of ideas this is the same as what the metaphysicians have sought to do, working abstractly, with their categories.

At this point, Mr. Andrews himself takes up the subject, on the side of ideas, or the American method, and pushes the simplification down to its utmost. He analyzes and further generalizes Webster's thirty-four classes of ideas, reducing them all to three grand major classes: 1. The idea of *division* or *apartness* (of, off, fromness); 2. The idea of *unity* or *togetherness* (at, to, with); and 3. The idea of vacillation between those two. These three ideas Mr. Andrews identifies with the *differentiation* and *integration* of Herbert Spencer, and with the coaction or interrelationship between those two ideas.

Mr. Andrews therefore entitles his method "The Ideological Method in Philology." His paper, which was long and elaborate, was listened to with the closest attention by the association throughout.

An Ironless Civilization.—Mr. A. Woeikof, in a narrative of his travels in Yucatan and the southeastern States of Mexico, published in "Petermann's Mittheilungen," introduces us to a so-called "civilized" people, who are practically unacquainted with the uses of iron. Writing about the northern portion of the State of Chiapas, he says that the inhabitants employ iron only in the shape of axes and machetes, which are imported from the United States. For the distance of one hundred kilometres round about Palenque not one blacksmith is to be found. Not a single nail is to be seen in their houses; everything is held together with cords or with vines. Even in the preparation of their usual article of food—tortillas—the apparatus they employ is equally primitive, though in this respect they follow the custom which is universal throughout all Mexico and Central America. The grains of maize are crushed between two stones, one of which, the nether one, is rather large, with a sloping upper surface. A woman kneels by this stone and strews upon it some grains of maize, over which she works to and fro another stone of cylindrical form, so grinding the maize. The coarse meal so obtained is baked into flat tortilla-cakes in the ashes. This is exactly the mode of preparing meal in vogue in Central and South Africa; the African negroes, however, show a higher grade of culture, inasmuch as they understand the working of iron. Our author caustically remarks hereupon that "the introduction even of hand-mills would be, for this country, a step of progress of far more value than many a high-sounding political prerogative, which can never be of any advantage to a population living in so low a grade of civilization."

A Two-Headed Snake.—H. Semler gives, in "Die Natur," an account of a living two-headed snake, found on the line of railroad from San José to Santa Cruz, and now on exhibition in the museum of the Woodward Garden in San Francisco. It is a gopher-snake (*Pelicophis Wilksei*), a species which lives on gophers, rats, mice, and small birds. The gopher-snake is a perfectly harmless reptile, like all the other snakes of California except the rattlesnake. The two-headed snake is twenty-two inches in length; its age can not be determined, but is not over two or three months; the full-grown snake is seven to eight feet in length. Its color is a dirty yellowish-white, with a double row of chestnut-brown spots along the back; these spots are nearly square and seventy-five in number. On each side is a row of smaller spots of the same color and shape. On both of the necks up to the heads are also several small spots. From the point where the necks fork to the extremities of the jaws is one inch and a half. The heads and necks are perfectly separate and about one inch apart; each head and each neck is fully formed and in every respect symmetrical. Each of the heads has two large eyes. The animal can put out each of the two forked tongues separately or together. The two jaws open into one throat. As each neck is perfectly flexible, the snake can turn each of its heads in any direction at pleasure. It oftentimes lays its two heads close together; often it spreads them as far apart as possible, or rests one upon the other. It takes its food through either mouth indifferently, and both jaws seem to possess the same power. Some years ago a Missouri farmer, in plowing, found a rattlesnake which in like manner had two fully-formed heads, and a merchant of San Francisco avers that he observed a similar *lusus naturæ* in a Java snake.

The Color-Sense in Savages.—In order to determine the capacity possessed by uncultivated races for distinguishing different colors and shades of color, Mr. Albert S. Gatschet prepared a series of colored paper slips, twenty in number, insensibly blending into each other, and by personal inquiry ascertained the names employed by various tribes of American Indians for designating these differences. The result, published in the "American Naturalist," does not throw much light on the question of color-blindness in uncivilized men, for we have here not a statement of what these Indians *see* in the way of color, but only of

what their idioms are able to express. Nevertheless, the author's conclusions, which apply only to seven Indian idioms, are interesting; they are as follows: 1. The Indians distinguish as many as, if not more *shades* of color, than we do. 2. No generic term meaning *color* exists, and it seems that such a term is too abstract for their conception. 3. Many of their color-terms, even the most opposite ones, are derived from one and the same radical syllable. For example, in the Kalapúya idiom *blue* is péi-ánkaf pawé-u, and *yellow* pé-i ántk pawé-u. 4. In the Indian lists we observe some names of mixed colors which impress the eye by being not homogeneous. Such is the Klamath term mä'kmäkli, which is the blue mixed with gray, as seen in wild geese and ducks; and gray in most of the dialects means black mixed in with white, or white with black, as in the fur of the raccoon, gray fox, etc. 5. In naming some colors Indians follow another principle than we do, in qualifying certain natural objects by their color, and then calling them by the same name, even when their color has been altered. This we distinctly observe in käkä'kli, *yellow* and *green* in Klamath, the adjective having been given originally to the color of grass, trees, and other plants. Most frequently *blue* and *green* are rendered by one and the same term. 6. As stated above, Indians often follow principles differing from ours in naming colors. The Klamath language has two terms for green, one when applied to the color of plants (käkä'kli), another when applied to garments and dress (tolalúptchi). So, too, *blue*, when said of beads, is expressed by a different word from the *blue* of flowers or of garments. 7. Reduplication of the word-root is very often met with in color-names, but the cause of this is not always the same. In Klamath and the Sahaptin dialects it is distribution and repetition (as of white hairs on a darker ground in the fur of the raccoon); in Dakota it is the idea of intensity that has produced this synthetic feature.

Draper's Researches on Oxygen in the Sun.—Professor Henry Draper, on the 13th of June, laid before the Royal Astronomical Society of London the evidence by which he claims to have demonstrated the existence of oxygen in the sun. A writer in the London "Times" (presumably Mr. J. Norman Lockyer) acknowledges the force of the evidence adduced by Professor Draper. He says: "We think that most spectroscopists will admit that Professor Draper does not pass beyond the limits of scientific caution in claiming that the coincidence shown in his photographs between the bright lines of oxygen and bright parts of the solar spectrum establishes the probability of the existence of oxygen in the sun. The burden of proof, or rather of disproof, should now fall on those who consider that the coincidence may, after all, be merely accidental. To us it seems that if such evidence as Professor Draper has obtained is rejected, hardly any spectroscopic evidence can suffice to prove the existence of an element in the sun. *We certainly have not stronger evidence in the case of sodium or magnesium*, elements which every physicist regards as present in the sun, than Professor Draper has obtained in the case of oxygen."

Telegraph Operators and Consumption.—Pulmonary consumption appears to be an exceptionally frequent cause of death among telegraphers, and one reason assigned for the fact is the peculiarly strained posture which an operator receiving messages continuously is obliged to assume in order not to lose the characters as they are ticked out to him from the sounder. "The operator in receiving bends his head and shoulder on his left side while listening to the sounder, this position confining his left lung and his heart in an unnatural position; and, being assumed day after day, month after month, eventually brings on the dread disease—consumption." But a writer in the "Journal of the Telegraph" suggests a different cause for the prevalence of consumption among telegraphers, viz., the original physical insufficiency of a large proportion of the young men who enter on this career. He says:

"In choosing an occupation for a young man, after he has received an education, if his health is not good, or if he should be of slight build, the question of his accepting a position requiring bodily labor is ignored entirely, and some field of usefulness

is sought that seems to require the least manual labor. Clerking in a store will not answer; it requires too much standing, and lifting of goods, etc. Clerking of any sort is not favored; he does not care to enter the professions—so called; and, in casting about, telegraphing seems so easy—nothing to do but sit at a table and write a little while; then, to vary the monotony, send a while with the key. This, to the uninitiated, appears very inviting, and the consequence is the young man becomes an applicant for a position in some telegraph-office, with a view of learning the art. This is not invariably the case, of course; but it is sufficiently so to justify the statement that more young men of delicate health seek telegraphing as an occupation than almost any other profession or trade, and the result is manifest in our mortality list."

We may remark that, just as the calling of the telegrapher *seems* to be an unhealthy one, owing to causes extraneous to itself, so newly-settled regions, as our Western Territories, often are credited with exceptional healthiness, to which they are not entitled. Such regions attract vigorous, adventurous young settlers, the very "pick and choice," physically, of the older settlements. Of course, among such a population disease is infrequent and the death-rate is low. It is an egregious fallacy, of course, to attribute this low death-rate to the benignity of the climate of their new home.

Discovery of a Remarkable Cave in Algeria.—The "Courier," of Tlemcen, Algeria, describes an interesting discovery, recently made, at the cascades near that place. Some miners had blasted an enormous rock near the cascades, and, on the removal of the *débris*, found it had covered a large opening into a cave, the floor of which was covered with water. Constructing a rude raft, and providing themselves with candles, the workmen sailed along this underground river, which at a distance of sixty metres was found to merge into a large lake of limpid water. The roof of the cavern was very high and covered with stalactites, the brilliant colors of which sparkled in the light of the candles. Continuing their course, the workmen had at certain places to navigate their craft between the stalactites which, meeting stalagmites from the bed of the lake, formed massive columns which looked as if they had been made expressly to sustain the enormous arches. Thus they reached the extremity of the lake, where they noticed a large channel extending southward. This is supposed to be a large fissure which has baffled exploration hitherto at Sebdon, and which connects the cascades with that locality, and thus with the mysterious sources of the Tafna. It is possible that here they have found an immense natural basin, supplied by powerful sources, and sending a part of its waters toward the lake, while the rest goes to Sebdon. The workmen estimated the distance underground traversed by them at three kilometres, and the breadth of the lake at two. They brought out with them a quantity of fishes, which swarmed round the raft, and which were found to be blind.

The Fodder-Tree.—It is proposed to introduce into India from Jamaica the *Calicandra saman*, a fodder-yielding tree supposed to be a native of the South American mainland. In Jamaica the tree is popularly known as the *guango.* It is a lofty tree, in general habit much resembling the English oak. The trunk is thick, generally short, and branched a few feet from the ground. The primary branch divisions are often tree-like in size, measuring nine to twelve feet in circumference at the base. The lower branches spread horizontally, and the upper are erect, spreading, giving the tree a flattish, dome-shaped appearance. Trees are not unfrequently seventy feet high, the diameter of whose branch expansion horizontally is over thirty feet. The shade which this tree affords is always flecked with gleams of sunshine which flit about as the branches wave with the breeze. This characteristic is coupled with the fact, which is of equal importance to healthy vegetation, that the leaves and leaflets rigidly close together at night, thus permitting the fall of dew on the ground under the branches. Grass grows freely within the overshadowing of its ample arms close up to its trunk. On this account alone it should be planted in pastures wherever it will thrive, as a grateful shade for cattle. But, further, it is itself

a valuable fodder-yielding tree. The fruit when ripe is a bright brown pod six to ten inches long, about an inch wide, and a quarter of an inch thick, the substance of the pod consisting of a sugary, amber-colored pulp. The pods are borne in great profusion. As they ripen they drop to the ground, and are picked up and eaten with much relish by all kinds of stock. The excellent quality of this fruit as a fodder is evident from its fattening effect — stock having access to it improve markedly during the time it is in season. The pods can be stored for use in winter and spring.

Another New Metal (?).—We take from "La Nature" a brief account of a new metal, *norwegium*, lately discovered by Dafil in an arseniuret of nickel, copper, and iron. Unlike most of the new elements latterly discovered, this new metal was *not* discovered by the aid of the spectroscope; indeed, Dafil does not appear to have examined its spectrum. The oxide of norwegium is easily reduced by carbon or by hydrogen; the metal is white, malleable, of the hardness of copper, and is fusible at a low red heat. Its density is equal to 9·44. It dissolves readily in hydrochloric acid; but nitric acid soon forms a nitrate. The concentrated solution is blue; on adding water it becomes green. Its chemical equivalent is 196 if the oxide is a protoxide. It is precipitated by potash, ammonia, and carbonate of soda, and redissolves in an excess of the precipitant. Sulphuretted hydrogen gives an insoluble brown precipitate in the sulpho-hydrate of ammonia. At the blowpipe, with borax, it forms a globule which is green while hot, but when cold, blue. The phosphorus salt yields a yellow globule, which on cooling becomes emerald green.

The Flight and Fall of Meteors.—Professor C. U. Shepard, in a paper on "Meteorites," read before the Connecticut Academy of Sciences, states the number of supposed independent falls of such bodies, whereof specimens are preserved in museums, as about three hundred and fifty, which number is increasing at the rate of between three and four per year. In the northern hemisphere there are two regions where falls of meteorites have been most frequent. "These regions," says Professor Shepard, "are apparently situated where they have been similarly influenced by the earth's magnetic polarity. The regions are on opposite sides of the hemisphere, have similar areas, and are in analogous directions and at similar distances from the two terrestrial north magnetic poles." The author calls attention to the highly magnetic constitution of nearly all meteorites, and to the fact that each mass, whether large or small, of a detonating meteor, maintains during its aërial flight a fixed axial direction. He infers that "if a strong magnetic force is found to attend these bodies, the perplexing subject relating to their high and variant velocities may receive some elucidation." He thinks that the great objection to the theory of the volcanic origin of meteorites, viz., that their velocity is too great, may be obviated by the hypothesis that acceleration may be produced by the electro-magnetism of the earth.

A Natural Well.—In March last a remarkable "sink-hole" was discovered in Meade County, Kansas. In May it was visited by Professor B. F. Mudge, who gives an interesting account of it in the "Kansas City Review of Science and Industry." This sink-hole made its appearance in a grassy prairie at a point forty miles south of Dodge, and its site was formerly crossed by a wagon-road. This road is little frequented, but those who passed over it early in March saw nothing new where now the sink-hole exists. About March 18th the road had disappeared, and in its place was a deep cavity. As seen by Professor Mudge on May 5th, it had the appearance of a gigantic well, sixty feet deep and 610 feet in circumference, being nearly circular. The walls were perpendicular, or nearly so. The material of the soil, at least to the depth of seventeen feet, consisted of a firm clay shale of reddish tinge. All around the cavity were circular cracks parallel to the rim, from five to fifteen feet deep, and from one to ten inches wide. These had opened at the time of the catastrophe, and appear as though ready to cave in; but one of the party that accompanied Professor Mudge had visited the spot a month earlier, and he

could not notice any change as having occurred in the interval. The depth of water at a few feet from the edge was from fifteen to twenty-seven feet; at the center it was forty-two feet: as the surface of the water was seventeen feet below the surface of the ground, the total depth of the cavity was sixty feet. The water is a strong brine, yielding one bushel of salt for forty-three gallons of the water.

Professor Mudge's explanation of the phenomenon is as follows: "The Dakota sandstone crops out in Clark County, twenty miles distant, and dips at a small angle toward this spot, and undoubtedly underlies the whole of Meade County. This sandstone is quite soft in some of its strata, and covered by harder beds. The softer portions are liable to be washed out by subterranean waters, and thus form caverns which are roofed by the hard layers. The cavern in this case became enlarged until the roof was unable to sustain the overlying prairie soil and shale, sixty feet in thickness, and the result is what we now behold. As what was the grass-grown prairie is now the bottom of the cavity, the height of the cavern must have been at least sixty feet, and its floor at least twice that distance (120 feet) below the traveled road. If it is still spread out in smaller chambers, other depressions like the present may occur."

Asphaltum and Amber in New Jersey.—In the neighborhood of Vincenttown, New Jersey, asphaltum and amber have been found, the former in the ash-marl, a layer above the green-sand proper; and the latter in the marl of the Cretaceous formation. Mr. E. Goldsmith, of the Academy of Natural Sciences of Philadelphia, describes the asphaltum as very brittle, black, with a resinous luster. Its fracture is uneven, inclined to conchoidal; the streak and powder brown. It melts easily in the flame, like wax, and burns with a yellow, smoky flame, leaving, after burning, a voluminous coal and but little ashes. The amber (or yellow mineral resin) was found at no great distance from the asphaltum. It occurs frequently in the marl of the Cretaceous formation, but not regularly: sometimes hundreds of tons of the marl may be looked over without finding a single piece of the amber; at other times enough has been found to fill a barrel within a day. According to Mr. Goldsmith, this mineral differs in several particulars from the typical amber found at the bottom or on the coast of the Baltic Sea. The former is lighter than water, the latter heavier. The Baltic amber fuses into a thick, sluggish fluid; the Vincenttown amber into a very fluid mobile liquid. It takes fire easily, and burns with a yellowish, strongly smoking flame, leaving but little coal, which rapidly burns away, and leaves a small quantity of dark-colored ashes.

NOTES.

Sir William Fothergill-Cooke, Wheatstone's associate in the work of introducing in England the electric telegraph, died June 25th, in the seventy-third year of his age.

There lately died in England the Rev. Canon Beadon, of Stoneham, who distinctly remembered some of the events of the Lord George Gordon riots in 1780. He was born in 1777, and succeeded his father in the "living" of Stoneham in 1812. He was fond of shooting and fishing; the former amusement he kept up till ninety-four, the latter till eighty-eight. At ninety-seven he had his first severe illness—an attack of bronchitis, and he was never after quite the same.

In Berlin there is a chemical laboratory, established by a society of housewives, for the examination of articles of food. It is directed by a competent chemist, who gives to the members of the society a course of lectures on practical chemistry. There is also a cookery-school under the patronage of the society. Domestic servants who have remained a certain number of years in one household (of a member of the society) are rewarded with prizes. The society also procures situations for domestic servants.

Among many new and interesting facts developed by Dr. Arthur Haviland in a recent discourse on the distribution of disease, was this, that the mortality of women from cancer is highest in those districts which skirt the banks of rivers subject to periodic floods. Having ascertained this fact, Dr. Haviland studied the physical and geological characters of the districts where cancer does not thrive, and found that all these districts are characterized by being high and dry, with non-retentive soils. The obvious conclusion for all this is, that patients who show tendency to cancer, or persons in

whose families cancer appears to be hereditary, should choose for their permanent residence high, dry sites. During the last twenty years no less than 100,000 women died from cancer in England.

Professor Cohn, of Breslau, has been making experiments with the electric light on the eyes of a number of persons, for the purpose of ascertaining its influence on visual perceptions and color-sensations. He finds that letters, spots, and colors are perceived at a much greater distance through the medium of the electric light than by day or gas light. The sensation of yellow is increased sixty fold compared to daylight, red six fold, blue two fold. Eyes which can only with difficulty distinguish colors by day or gas light, are much aided by the electric light.

A curious survival of an old-time institution exists in some remote places in England, viz., the official ale-taster. The ale-taster takes an oath to "try, taste, and assize the beer and ale put on sale" in his district "whether the same be wholesome for man's body." The old ale taster's method of "analyzing" beer for the purpose of detecting the addition of sugar to the liquor was rather primitive. Like most men in those times, he wore leather breeches, and, when he went to test the ale for the presence of sugar, a pint of fluid was spilt on a well-cleaned bench, and the taster sat upon it till it dried. If, on rising, the seat of the breeches stuck to the bench, then sugar was present, but if not the beer was pure.

In the Himalayas, says "Das Ausland," is found a plant of the family *Aroideæ*, which strikingly resembles a cobra with its head erect: it is known as the cobra-plant. The half-moon-shaped markings on the cobra's head, and the lines on its neck, are imitated in the flower-sheath of the plant, while the tongue-like elongation of the pistil and of the midrib of the flower-sheath serve to increase the resemblance of the plant to a living animal. Indeed, so striking is this resemblance, that on coming upon it unawares a person instinctively recoils with horror.

Professor Emerson Reynolds, of Dublin, has discovered a new explosive, compounded of two substances, which can be kept apart without risk, and can be mixed as required to form a blasting agent. The powder is a mixture of seventy-five parts of chlorate of potassium with twenty-five parts of "sulphurea," a body discovered by Professor Reynolds, which can be obtained cheaply from a waste product of gas manufacture. The new explosive is a white powder, which can be ignited at a lower temperature than gunpowder, and leaves less solid residue.

A first trial has recently been made at Woolwich, England, of a new gun having the following dimensions: Length, 36 feet; diameter at breech, 6 feet 6 inches; diameter at muzzle, 2 feet 4 inches; depth of bore, 33 feet; caliber in powder-chamber, $19\frac{3}{4}$ inches; caliber at muzzle, $17\frac{3}{4}$ inches. The gun weighs a hundred tons, carries a shot weighing one ton, and the first time it was fired received a charge of 440 pounds of powder.

A report of the Medical Department of the Russian Army shows that, of the 1,400,000 boys registered as having been born in 1855, there were living in 1876 only 610,000, or $43\frac{1}{2}$ per cent.

A "very peculiar, if not unique" case of albinism is recorded in the "Lancet." The subject is a girl of eleven years of age, having pink eyes, with the usual photophobia, but *hair of a bright-red color.*

A new process for making artificial stone, invented by Ternikoff, is thus described in "Le Monde de la Science": A mortar consisting of equal parts of lime and sand is exposed for a few hours to a temperature of 150° Centigrade in the presence of water-vapor. The paste having been taken out of the furnace is now passed under the cylinders of a machine like that used for molding bricks, and it comes out in the form of cubes which, on being exposed to the air, become dry and hard. In the course of eight or nine hours these cubes are as hard as good building stones, and are fit for use. This artificial stone is in fact a sort of brick of mortar baked at a low temperature, and the cost, too, is about the same as that of bricks.

In the Rotorua District, New Zealand, are several hot springs, one of which at least differs essentially from any other thermal spring of which we have any knowledge. This is Tapui Te Koutu, a pool eighty feet deep, with a temperature of 90° to 100° when the wind is westerly or southerly; but, if a change of wind to north or east takes place, the water rises four feet and the temperature to 180°! Turi-Kore is a waterfall with a temperature of 96° to 120°, and is in high repute among the Maoris for the cure of all cutaneous diseases. Kuirau, 136° to 156°, is so soft that clothes can be washed in it without soap. Koroteoteo, a boiling spring, 214°, is known as the "Oil-bath." Kauwhanga, a powerful sulphur-bath, bears the name of the "Painkiller." Ti Kute, the Great Spring, three-quarters of an acre in extent, boiling furiously and always throwing off great clouds of steam, is reported to be "wonderfully efficacious in cases of rheumatism and cutaneous diseases."

EDWARD FRANKLAND.

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PROTOPLASM AND LIFE.*

BY PROFESSOR G. J. ALLMAN, LL.D., F.R.S.,
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MORE than forty years have now passed away since the French naturalist, Dujardin, drew attention to the fact that the bodies of some of the lowest members of the animal kingdom consist of a structureless, semi-fluid, contractile substance, to which he gave the name of Sarcode. A similar substance occurring in the cells of plants was afterward studied by Hugo von Mohl, and named by him Protoplasm. It remained for Max Schultze to demonstrate that the sarcode of animals and the protoplasm of plants were identical.

The conclusions of Max Schultze have been in all respects confirmed by subsequent research, and it has further been rendered certain that this same protoplasm lies at the base of all the phenomena of life, whether in the animal or the vegetable kingdom. Thus has arisen the most important and significant generalization in the whole domain of biological science.

Within the last few years protoplasm has again been made a subject of special study; unexpected and often startling facts have been brought to light, and a voluminous literature has gathered round this new center of research. I believe, therefore, that I can not do better than call your attention to some of the more important results of these inquiries, and endeavor to give you some knowledge of the properties of protoplasm, and of the part it plays in the two great kingdoms of organic nature.

As has just been said, protoplasm lies at the base of every vital phenomenon. It is, as Huxley has well expressed it, "the physical basis of life." Wherever there is life, from its lowest to its highest

* Inaugural Address at the Sheffield meeting, August 20, 1879.

manifestations, there is protoplasm; wherever there is protoplasm, there, too, is life. Thus, coextensive with the whole of organic nature—every vital act being referable to some mode or property of protoplasm—it becomes to the biologist what the ether is to the physicist; only that instead of being an hypothetical conception, accepted as a reality from its adequacy in the explanation of phenomena, it is a tangible and visible reality, which the chemist may analyze in his laboratory, the biologist scrutinize beneath his microscope and his dissecting needle.

The chemical composition of protoplasm is very complex, and has not been exactly determined. It may, however, be stated that protoplasm is essentially a combination of albuminoid bodies, and that its principal elements are, therefore, oxygen, carbon, hydrogen, and nitrogen. In its typical state it presents the condition of a semi-fluid substance—a tenacious, glairy liquid, with a consistence somewhat like that of the white of an unboiled egg.* While we watch it beneath the microscope, movements are set up in it: waves traverse its surface, or it may be seen to flow away in streams, either broad and attaining but a slight distance from the main mass, or else stretching away far from their source, as narrow liquid threads, which may continue simple, or may divide into branches, each following its own independent course; or the streams may flow one into the other, as streamlets would flow into rivulets and rivulets into rivers, and this not only where gravity would carry them, but in a direction diametrically opposed to gravitation: now we see it spreading itself out on all sides into a thin liquid stratum, and again drawing itself together within the narrow limits which had at first confined it, and all this without any obvious impulse from without which would send the ripples over its surface or set the streams flowing from its margin. Though it is certain that all these phenomena are in response to some stimulus exerted on it by the outer world, they are such as we never meet with in a simply physical fluid—they are spontaneous movements resulting from its proper irritability, from its essential constitution as living matter.

Examine it closer, bring to bear on it the highest powers of your microscope—you will probably find disseminated through it countless multitudes of exceedingly minute granules; but you may also find it absolutely homogeneous, and, whether containing granules or not, it is certain that you will find nothing to which the term *organization*

* In speaking of protoplasm as a liquid, it must be borne in mind that this expression refers only to its physical consistence—a condition depending mainly on the amount of water with which it is combined, and subject to considerable variation, from the solid form in which we find it in the dormant embryo of seeds, to the thin, watery state in which it occurs in the leaves of Valisneria. Its distinguishing properties are totally different from those of a purely physical liquid, and are subject to an entirely different set of laws.

can be applied. You have before you a glairy, tenacious fluid, which, if not absolutely homogeneous, is yet totally destitute of structure.

And yet no one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life.

The picture which I have thus endeavored to trace for you in a few leading outlines is that of protoplasm in its most generalized aspect. Such generalizations, however, are in themselves unable to satisfy the conditions demanded by an exact scientific inquiry, and I propose now, before passing to the further consideration of the place and purport of protoplasm in nature, to bring before you some definite examples of protoplasm, such as are actually met with in the organic world.

A quantity of a peculiar slimy matter was dredged in the North Atlantic by the naturalists of the exploring-ship Porcupine from a depth of from 5,000 to 25,000 feet. It is described as exhibiting, when examined on the spot, spontaneous movements, and as being obviously endowed with life. Specimens of this, preserved in spirits, were examined by Professor Huxley, and declared by him to consist of protoplasm, vast masses of which must thus in a living state extend over wide areas of sea-bottom. To this wonderful slime Huxley gave the name of *Bathybius Haeckelii*.

Bathybius has since been subjected to an exhaustive examination by Professor Haeckel, who believes that he is able to confirm in all points the conclusions of Huxley, and arrives at the conviction that the bottom of the open ocean at depths below 5,000 feet is covered with an enormous mass of living protoplasm, which lingers there in the simplest and most primitive condition, having as yet acquired no definite form. He suggests that it may have originated by spontaneous generation, but leaves this question for future investigations to decide.

The reality of Bathybius, however, has not been universally accepted. In the more recent investigations of the Challenger the explorers have failed in their attempts to bring further evidence of the existence of masses of amorphous protoplasm spreading over the bed of the ocean. They have met with no trace of Bathybius in any of the regions explored by them, and they believe that they are justified in the conclusion that the matter found in the dredgings of the Porcupine and preserved in spirits for further examination, was only an inorganic precipitate due to the action of the alcohol.

It is not easy to believe, however, that the very elaborate investigations of Huxley and Haeckel can be thus disposed of. These, moreover, have received strong confirmation from the still more recent observations of the Arctic voyager Bessels, who was one of the explorers of the ill-fated Polaris, and who states that he dredged from the Greenland seas masses of living undifferentiated protoplasm.

Bessels assigns to these the name of Protobathybius, but they are apparently indistinguishable from the Bathybius of the Porcupine. Further arguments against the reality of Bathybius will therefore be needed before a doctrine founded on observations so carefully conducted shall be relegated to the region of confuted hypotheses.

Assuming, then, that Bathybius, however much its supposed wide distribution may have been limited by more recent researches, has a real existence, it presents us with a condition of living matter the most rudimental it is possible to conceive. No law of morphology has as yet exerted itself in this formless slime. Even the simplest individualization is absent. We have a living mass, but we know not where to draw its boundary-lines; it is living matter, but we can scarcely call it a living being.

We are not, however, confined to Bathybius for examples of protoplasm in a condition of extreme simplicity. Haeckel has found, inhabiting the fresh waters in the neighborhood of Jena, minute lumps of protoplasm which, when placed under the microscope, were seen to have no constant shape, their outline being in a state of perpetual change, caused by the protrusion from various parts of their surface of broad lobes and thick, finger-like projections, which, after remaining visible for a time, would be withdrawn, to make their appearance again on some other part of the surface.

These changeable protrusions of its substance, without fixed position or definite form, are eminently characteristic of protoplasm in some of its simplest conditions. They have been termed "Pseudopodia," and will frequently come before you in what I have yet to say.

To the little protoplasmic lumps thus constituted Haeckel has given the name of *Protamœba primitiva*. They may be compared to minute detached pieces of Bathybius. He has seen them multiplying themselves by spontaneous division into two pieces, which, on becoming independent, increase in size, and acquire all the characters of the parent.

Several other beings as simple as *Protamœba* have been described by various observers, and especially by Haeckel, who brings the whole together into a group to which he gives the name of MONERA, suggested by the extreme simplicity of the beings included in it.

But we must now pass to a stage a little higher in the development of protoplasmic beings. Widely distributed in the fresh and salt waters of Britain, and probably of almost all parts of the world, are small particles of protoplasm closely resembling the *Protamœba* just described. Like it, they have no definite shape, and are perpetually changing their form, throwing out and drawing in thick lobes and finger-like pseudopodia, in which their body seems to flow away over the field of the microscope. They are no longer, however, the homogeneous particle of protoplasm which forms the body of *Protamœba*. Toward the center a small globular mass of firmer protoplasm has

become differentiated off from the remainder, and forms what is known as a nucleus, while the protoplasm forming the extreme outer boundary differs slightly from the rest, being more transparent, destitute of granules, and apparently somewhat firmer than the interior. We may also notice that at one spot a clear spherical space has made its appearance, but that while we watch it has suddenly contracted and vanished, and after a few seconds has begun to dilate so as again to come into view, once more to disappear, then again to return, and all this in regular rhythmical sequence. This little rhythmically pulsating cavity is called the "contractile vacuole." It is of very frequent occurrence among those beings which lie low down in the scale of life.

We have now before us a being which has arrested the attention of naturalists almost from the commencement of microscopical observation. It is the famous *Amœba*, for which ponds and pools and gutters on the house-roof have for the last two hundred years been ransacked by the microscopist, who has many a time stood in amazement at the undefinable form and Protean changes of this particle of living matter. It is only the science of our own days, however, which has revealed its biological importance, and shown that in this little soft, nucleated particle we have a body whose significance for the morphology and physiology of living beings can not be over-estimated, for in *Amœba* we have the essential characters of a CELL, the morphological unit of organization, the physiological source of specialized function.

The term "cell" has been so long in use that it can not now be displaced from our terminology; and yet it tends to convey an incorrect notion, suggesting as it does the idea of a hollow body or vesicle, this having been the form under which it was first studied. The cell, however, is essentially a definite mass of protoplasm having a nucleus imbedded in it. It may or may not assume the form of a vesicle; it may or may not be protected by an enveloping membrane; it may or may not contain a contractile vacuole; and the nucleus may or may not contain within it one or more minute secondary nuclei or "nucleoli."

Haeckel has done good service to biology in insisting on the necessity of distinguishing such non-nucleated forms as are presented by *Protamœba* and the other *Monera* from the nucleated forms as seen in *Amœba*. To the latter he would restrict the word *cell*, while he would assign that of "cytode" to the former.

Let us observe our *Amœba* a little closer. Like all living beings, it must be nourished. It can not grow as a crystal would grow by accumulating on its surface molecule after molecule of matter. It must *feed*. It must take into its substance the necessary nutriment; it must assimilate this nutriment, and convert it into the material of which it is itself composed.

If we seek, however, for a mouth by which the nutriment can enter into its body, or a stomach by which this nutriment can be digest-

ed, we seek in vain. Yet watch it for a moment as it lies in a drop of water beneath our microscope. Some living denizen of the same drop is in its neighborhood, and its presence exerts on the protoplasm of the *Amœba* a special stimulus which gives rise to the movements necessary for the prehension of nutriment. A stream of protoplasm instantly runs away from the body of the *Amœba* toward the destined prey, envelops it in its current, and then flows back with it to the central protoplasm, where it sinks deeper and deeper into the soft, yielding mass, and becomes dissolved, digested, and assimilated in order that it may increase the size and restore the energy of its captor.

But again, like all living things, *Amœba* must multiply itself, and so after attaining a certain size its nucleus divides into two halves, and then the surrounding protoplasm becomes similarly cleft, each half retaining one half of the original nucleus. The two new nucleated masses which thus arise now lead an independent life, assimilate nutriment, and attain the size and characters of the parent.

We have just seen that in the body of an *Amœba* we have the type of a cell. Now, both the fresh waters and the sea contain many living beings besides *Amœba* which never pass beyond the condition of a simple cell. Many of these, instead of emitting the broad, lobe-like pseudopodia of *Amœba*, have the faculty of sending out long, thin threads of protoplasm, which they can again retract, and by the aid of which they capture their prey or move from place to place. Simple structureless protoplasm as they are, many of them fashion for themselves an outer membranous or calcareous case, often of symmetrical form and elaborate ornamentation, or construct a silicious skeleton of radiating spicula, or crystal clear concentric spheres of exquisite symmetry and beauty.

Some move about by the aid of a flagellum, or long whip-like projection of their bodies, by which they lash the surrounding waters, and which, unlike the pseudopodia of *Amœba*, can not, during active life, be withdrawn into the general protoplasm of the body; while among many others locomotion is effected by means of cilia—microscopic vibratile hairs, which are distributed in various ways over the surface, and which, like the pseudopodia and flagella, are simple prolongations of their protoplasm.

In every one of these cases the entire body has the morphological value of a cell, and in this simple cell reside the whole of the properties which manifest themselves in the vital phenomena of the organism.

The part fulfilled by these simple unicellular beings in the economy of nature has at all times been very great, and many geological formations, largely built up of their calcareous or silicious skeletons, bear testimony to the multitudes in which they must have swarmed in the waters of the ancient earth.

Those which have thus come down to us from ancient times owe

their preservation to the presence of the hard, persistent structures secreted by their protoplasm, and must, after all, have formed but a very small proportion of the unicellular organisms which peopled the ancient world, and there fulfilled the duties allotted to them in nature, but whose soft, perishable bodies have left no trace behind.

In our own days similar unicellular organisms are at work, taking their part silently and unobtrusively in the great scheme of creation, and mostly destined, like their predecessors, to leave behind them no record of their existence. The Red-Snow plant, to which is mainly due the beautiful phenomenon by which tracts of Arctic and Alpine snow become tinged of a delicate crimson, is a microscopic organism whose whole body consists of a simple spherical cell. In the protoplasm of this little cell must reside all the essential attributes of life; it must grow by the reception of nutriment; it must repeat by multiplication that form which it has itself inherited from its parent; it must be able to respond to the stimulus of the physical conditions by which it is surrounded. And there it is, with its structure almost on the bounds of extremest simplification, taking its allotted part in the economy of nature, combining into living matter the lifeless elements which lie around it, redeeming from sterility the regions of never-thawing ice, and peopling with its countless millions the wastes of the snow-land.*

But organization does not long rest on this low stage of unicellular simplicity, for, as we pass from these lowest forms into higher, we find cell added to cell, until many millions of such units become associated in a single organism, where each cell, or each group of cells, has its own special work, while all combine for the welfare and unity of the whole.

In the most complex animals, however, even in man himself, the component cells, notwithstanding their frequent modification and the usual intimacy of their union, are far from losing their individuality. Examine under the microscope a drop of blood freshly taken from the human subject, or from any of the higher animals. It is seen to be composed of a multitude of red corpuscles, swimming in a nearly colorless liquid, and along with these, but in much smaller numbers, somewhat larger colorless corpuscles. The red corpuscles are modified cells, while the colorless corpuscles are cells still retaining their typical form and properties. These last are little masses of protoplasm, each enveloping a central nucleus. Watch them. They will be seen to change their shape; they will project and withdraw pseudopodia, and creep about like an *Amœba*. But, more than this, like an *Amœba*, they will take in solid matter as nutriment. They may be fed with

* The Red-Snow plant (*Protococcus nivalis*) acts on the atmosphere through the agency of chlorophyl, like the ordinary green plants. As in these, chlorophyl is developed in it, and is only withdrawn from view by the predominant red pigment to which the Protococcus owes one of its most striking characteristics.

colored food, which will then be seen to have accumulated in the interior of their soft, transparent protoplasm; and in some cases the colorless blood-corpuscles have actually been seen to devour their more diminutive companions, the red ones.

Again, there are certain cells filled with peculiar colored matters, and called pigment-cells, which are especially abundant, as constituents of the skin, in fishes, frogs, and other low vertebrate, as well as many invertebrate, animals. Under certain stimuli, such as that of light, or of emotion, these pigment-cells change their form, protrude or retract pseudopodial prolongations of their protoplasm, and assume the form of stars or of irregularly lobed figures, or again draw themselves together into little globular masses. To this change of form in the pigment-cell the rapid change of color, so frequently noticed in the animals provided with them, is to be attributed.

The animal egg, which in its young state forms an element in the structure of the parent organism, possesses in the relations now under consideration a peculiar interest. The egg is a true cell, consisting essentially of a lump of protoplasm inclosing a nucleus, and having a nucleolus included in the interior of the nucleus. While still very young it has no constant form, and is perpetually changing its shape. Indeed, it is often impossible to distinguish it from the *Amœba;* and it may, like an *Amœba*, wander from place to place by the aid of its pseudopodial projections. I have shown elsewhere * that the primitive egg of the remarkable hydroid *Myriothela* manifests amœboid motions; while Haeckel has shown † that in the sponges certain *Amœba*-like organisms, which are seen wandering about in the various canals and cavities of their bodies, and had been until lately regarded as parasites which had gained access from without, are really the eggs of the sponge; and a similar amœboid condition is presented by the very young eggs of even the highest animals.

Again, Reichenbach has proved ‡ that during the development of the crawfish the cells of the embryo throw out pseudopodia by which, exactly as in an *Amœba*, the yolk-spheres, which serve as nutriment for the embryo, are surrounded and ingulfed in the protoplasm of the cells.

I had shown some years ago § that in *Myriothela* pseudopodial processes are being constantly projected from the walls of the alimentary canal into its cavity. They appear as direct extensions of a layer of clear, soft, homogeneous protoplasm, which lies over the surface of the naked cells lining the cavity, and which I now regard as the

* "On the Structure and Development of *Myriothela*," "Philosophical Transactions," vol. clxv., 1875, p. 552.

† "Jenaische Zeitschrift," 1871.

‡ "Die Embryonanlage und erste Entwickelung des Flusskrebse," "Zeitschrift für wissenschaftliche Zoologie," 1877.

§ *Loc. cit.*

"Hautschicht," or cortical layer, of these cells. I then suggested that the function of these pseudopodia lay in seizing, in the manner of an *Amœba*, such alimentary matter as may be found in the contents of the canal, and applying it to the nutrition of the hydroid.

What I had thus suggested with regard to *Myriothela* has been since proved in certain planarian worms by Metschnikoff,* who has seen the cells which line the alimentary canal in these animals act like independent *Amœbæ*, and ingulf in their protoplasm such solid nutriment as may be contained in the canal. When the planaria was fed with coloring matter these amœboid cells became gorged with the colored particles just as would have happened in an *Amœba* when similarly fed.

But it is not alone in such loosely aggregated cells as those of the blood, or in the amœboid cells of the alimentary canal, or in such scattered constituents of the tissues as the pigment-cells, or in cells destined for an ultimate state of freedom, as the egg, that there exists an independence. The whole complex organism is a society of cells, in which every individual cell possesses an independence, an autonomy, not at once so obvious as in the blood-cells, but not the least real. With this autonomy of each element there is at the same time a subordination of each to the whole, thus establishing a unity in the entire organism, and a concert and harmony between all the phenomena of its life.

In this society of cells each has its own work to perform, and the life of the organism is made up of the lives of its component cells. Here it is that we find most distinctly expressed the great law of the physiological division of labor. In the lowest organisms, where the whole being consists of a single cell, the performance of all the processes which constitute its life must devolve on the protoplasm of this one cell; but as we pass to more highly organized beings, the work becomes distributed among a multitude of workers. These workers are the cells which now make up the complex organism. The distribution of labor, however, is not a uniform one, and we are not to suppose that the work performed by each cell is but a repetition of that of every other. For the life-processes, which are accumulated in the single cell of the unicellular organism become in the more complex organism differentiated, some being intensified and otherwise modified and allocated to special cells, or to special groups of cells, which we call organs, and whose proper duty is now to take charge of the special processes which have been assigned to them. In all this we have a true division of labor—a division of labor, however, by no means absolute; for the processes which are essential to the life of the cell must still continue common to all the cells of the organism. No cell, however great may be the differentiation of function in the organism,

* "Ueber die Verdauungsorgane einiger Süsswasser-Turbellarien," "Zoologischer Anzeiger," December, 1878.

can dispense with its irritability, the one constant and essential property of every living cell. There thus devolves on each cell or group of cells some special work which contributes to the well-being of all, and their combined labors secure the necessary conditions of life for every cell in the community, and result in those complex and wonderful phenomena which constitute the life of the higher organisms.

We have hitherto considered the cell only as a mass of active nucleated protoplasm, either absolutely naked, or partially inclosed in a protective case, which still permits free contact of the protoplasm with the surrounding medium. In very many instances, however, the protoplasm becomes confined within resisting walls, which entirely shut it in from all direct contact with the medium which surrounds it. With the plant this is almost always so after the earliest stages of its life. Here the protoplasm of the cells is endowed with the faculty of secreting over its surface a firm, resisting membrane, composed of cellulose, a substance destitute of nitrogen, thus totally different from the contained protoplasm, and incapable of manifesting any of the phenomena of life..

Within the walls of cellulose the protoplasm is now closely imprisoned, but we are not on that account to suppose that it has lost its activity, or has abandoned its work as a living being. Though it is now no longer in direct contact with the surrounding medium, it is not the less dependent on it, and the reaction between the imprisoned protoplasm and the outer world is still permitted by the permeability of the surrounding wall of cellulose.

When the protoplasm thus becomes surrounded by a cellulose wall it seldom retains the uniform arrangement of its parts which is often found in the naked cells. Minute cavities or vacuoles make their appearance in it; these increase in size and run one into the other, and may finally form one large cavity in the center, which becomes filled with a watery fluid, known as the cell-sap. This condition of the cell was the first observed, and it was it which suggested the often inapplicable term "cell." By the formation of this central sap cavity the surrounding protoplasm is pushed aside, and pressed against the cellulose wall, over which it now extends as a continuous layer. The nucleus either continues near the center, enveloped by a layer of protoplasm, which is connected by radiating bands of protoplasm with that of the walls, or it accompanies the displaced protoplasm, and lies imbedded in this on the walls of the cell.

We have abundant evidence to show that the imprisoned protoplasm loses none of its activity. The *Characeæ* constitute an exceedingly interesting group of simple plants, common in the clear water of ponds and of slowly running streams. The cells of which they are built up are comparatively large, and, like almost all vegetable cells, are each inclosed in a wall of cellulose. The cellulose is perfectly transparent, and if the microscope, even with a low power, be brought

to bear on one of these cells, a portion of its protoplasm may be seen in active rotation, flowing up one side of the long, tubular cell and down the other, and sweeping on with it such more solid particles as may become enveloped in its current. In another water-plant, the *Vulisneria spiralis*, a similar active rotation of the protoplasm may be seen in the cells of the leaf, where the continuous stream of liquid protoplasm sweeping along the green granules of chlorophyl, and even carrying the globular nucleus with it in its current, presents one of the most beautiful of the many beautiful phenomena which the microscope has revealed to us.

In many other cells with large sap-cavities, such as those which form the stinging hairs of nettles and other kinds of vegetable hairs, the protoplasmic lining of the wall may send off into the sap-cavity projecting ridges and strings, forming an irregular network, along which, under a high power of the microscope, a slow streaming of granules may be witnessed. The form and position of this protoplasmic network undergo constant changes, and the analogy with the changes of form in an *Amœba* becomes obvious. The external wall of cellulose renders it impossible for the confined protoplasm to emit, like a naked *Amœba*, pseudopodia from its outer side; but on the inner side there is no obstacle to the extension of the protoplasm, and here the cavity of the cell becomes more or less completely traversed by protoplasmic projections from the wall. These often stretch themselves out in the form of thin filaments, which, meeting with a neighboring one, become fused into it; they show currents of granules streaming along their length, and after a time become withdrawn and disappear. The vegetable cell, in short, with its surrounding wall of cellulose, is in all essential points a closely imprisoned rhizopod.

Further proof that the imprisoned protoplasm has lost by its imprisonment none of its essential irritability, is afforded by the fact that if the transparent cell of a Nitella, one of the simple water-plants just referred to, be touched under the microscope with the point of a blunt needle, its green protoplasm will be seen to recede, under the irritation of the needle, from the cellulose wall. If the cellulose wall of the comparatively large cell which forms the entire plant in a Vaucheria, a unicellular alga very common in shallow ditches, be ruptured under the microscope, its protoplasm will escape, and may then be often seen to throw out pseudopodial projections and exhibit amœboid movements.

Even in the higher plants, without adducing such obvious and well-known instances as those of the sensitive-plant and Venus's flytrap, the irritability of the protoplasm may be easily rendered manifest. There are many herbaceous plants, in which, if the young, succulent stem of a vigorously growing specimen receive a sharp blow, of such a nature, however, as not to bruise its tissues, or in any way wound it, the blow will sometimes be immediately followed by a drooping of the

stem commencing at some distance above the point to which the stroke had been applied; its strength appears to have here suddenly left it; it is no longer able to bear its own weight, and seems to be dying. The protoplasm, however, of its cells, is in this instance not killed, it is only stunned by the violence of the blow, and needs time for its restoration. After remaining, it may be for some hours, in this drooping and flaccid state, the stem begins to raise itself, and soon regains its original vigor. This experiment will generally succeed well in plants with a rather large terminal spike or raceme, when the stroke is applied some little distance below the inflorescence shortly before the expansion of the flower.

In the several instances now adduced, the protoplasm is in the mature state of the plant entirely included within a wall of cellulose. Some recent beautiful observations, however, of Mr. Francis Darwin have shown that even in the higher plants truly naked protoplasm may occur. From the cells of certain glandular hairs contained within the cup-like receptacles formed by the united bases of two opposite leaves in the teasel (*Dipsacus*), he has seen emitted long, pseudopodia-like projections of the protoplasm. What may be the significance of this very exceptional phenomenon is still undetermined. It is probably, as Mr. Darwin supposes, connected with the absorption of nitrogenous matter.

That there is no essential difference between the protoplasm of plants and that of animals is rendered further evident by other motor phenomena, which we are in the habit of regarding as the exclusive attribute of animals. Many of the more simply organized plants give origin to peculiar cells called spores, which separate from the parent, and, like the seeds of the higher plants, are destined to repeat its form. In many cases these spores are eminently locomotive. They are then termed "swarm-spores," and their movements are brought about, sometimes by changes of shape, when they move about in the manner of an *Amœba*, but more frequently by minute vibratile cilia, or by more strongly developed flagella or whip-like projections of their protoplasm. These cilia and flagella are absolutely indistinguishable from similar structures widely distributed among animals, and by their vibratory or lashing strokes upon the surrounding water the swarm-spores are rapidly carried from place to place. In these motions they often present a curious semblance of volition, for if the swarm-spore meet with an obstacle in its course, it will, as if to avoid it, change the direction of its motion, and retreat by a reversion of the stroke of its cilia. They are usually attracted by light, and congregate at the light side of the vessel which contains them, though in some cases light has the opposite effect on them, and they recede from it.

Another fact may here be adduced to show the uniform character of protoplasm, and how very different are its properties from those of lifeless matter, namely, the faculty which all living protoplasm possesses

of resisting the entrance of coloring matter into its substance. As many here present are aware, microscopists are in the habit of using in their investigations various coloring matters, such as solutions of carmine. These act differently on the different tissues, staining some, for example, more deeply than others, and thus enabling the histologist to detect certain elements of structure, which would otherwise remain unknown. Now, if a solution of carmine be brought into contact with living protoplasm, this will remain, so long as it continues alive, unaffected by the coloring matter. But if the protoplasm be killed, the carmine will at once pervade its whole substance, and stain it throughout with a color more intense than even that of the coloring solution itself.

But no more illustrative example can be offered of the properties of protoplasm as living matter, independently of any part it may take in organization, than that presented by the *Myxomycetæ*.

The *Myxomycetæ* constitute a group of remarkable organisms, which, from their comparatively large size and their consisting, during a great part of their lives, of naked protoplasm, have afforded a fine field for research, and have become one of the chief sources from which our knowledge of the nature and phenomena of protoplasm has been derived.

They have generally been associated by botanists with the fungi, but though their affinities with these are perhaps closer than with any other plants, they differ from them in so many points, especially in their development, as to render this association untenable. They are found in moist situations, growing on old tan or on moss, or decaying leaves or rotten wood, over which they spread in the form of a network of naked protoplasmic filaments, of a soft, creamy consistence, and usually of a yellowish color.

Under the microscope the filaments of the network exhibit active spontaneous movements, which, in the larger branches, are visible under an ordinary lens, or even by the naked eye. A succession of undulations may then be noticed passing along the course of the threads. Under higher magnifying powers a constant movement of granules may be seen flowing along the threads, and streaming from branch to branch of this wonderful network. Here and there offshoots of the protoplasm are projected, and again withdrawn in the manner of the pseudopodia of an *Amœba*, while the whole organism may be occasionally seen to abandon the support over which it had grown, and to creep over neighboring surfaces, thus far resembling in all respects a colossal ramified *Amœba*. It is also curiously sensitive to light, and may be sometimes found to have retreated during the day to the dark side of the leaves, or into the recesses of the tan over which it had been growing, and again to creep out on the approach of night.

After a time there arise from the surface of this protoplasmic net oval capsules or spore-cases, in which are contained the spores or repro-

ductive bodies of the *Myxomycetæ.* When the spore-case has arrived at maturity, it bursts and allows the spores to escape. These are in the form of spherical cells, each included in a delicate membranous wall, and when they fall into water the wall becomes ruptured, and the little cell creeps out. This consists of a little mass of protoplasm with a round central nucleus, inclosing a nucleolus, and with a clear vacuole, which exhibits a rhythmically pulsating movement. The little naked spore thus set at liberty is soon seen to be drawn out at one point into a long, vibratile, whip-like flagellum, which by its lashing action carries the spore from place to place. After a time the flagellum disappears, and the spore may now be seen emitting and withdrawing finger-like pseudopodia, by means of which it creeps about like an *Amœba*, and like an *Amœba* devours solid particles by ingulfing them in its soft protoplasm.

So far these young *Amœba*-like *Myxomycetæ* have enjoyed each an independent existence. Now, however, a singular and significant phenomenon is presented. Two or more of these *Myxamœbæ*, as they have been called, approach one another, come into contact, and finally become completely fused together into a single mass of protoplasm, in which the components are no longer to be distinguished. To the body thus formed by the fusion of the *Myxamœbæ* the name of "plasmodium" has been given.

The plasmodium continues, like the simple amœbiform bodies of which it is composed, to grow by the ingestion and assimilation of solid nutriment, which it envelops in its substance; it throws out ramifying and mosculating processes, and finally becomes converted into a protoplasmic network, which in its turn gives rise to spore-cases with their contained spores, and thus completes the cycle of its development.

Under certain external conditions, the *Myxomycetæ* have been observed to pass from an active mobile state into a resting state, and this may occur both in the amœbiform spores and in the plasmodium. When the plasmodium is about to pass into a resting state, it usually withdraws its finer branches, and expels such solid ingesta as may be included in it. Its motions then gradually cease, it breaks up into a multitude of polyhedral cells, which, however, remain connected, and the whole body dries into a horny brittle mass, known by the name of "sclerotium."

In this condition, without giving the slightest sign of life, the sclerotium may remain for many months. Life, however, is not destroyed; its manifestations are only suspended; and if after an indefinite time the apparently dead sclerotium be placed in water, it immediately begins to swell up, the membranous covering of its component cells becomes dissolved and disappears, and the cells themselves flow together into an active amœboid plasmodium.

We have already seen that every cell possesses an autonomy or in-

dependent individuality, and from this we should expect that, like all living beings, it had the faculty of multiplying itself, and of becoming the parent of other cells. This is truly the case, and the process of cell-multiplication has of late years been studied, with the result of adding largely to our knowledge of the phenomena of life.

The labors of Strasburger, of Auerbach, of Oscar Hertwig, of Eduard van Beneden, Bütschli, Fol, and others, here come prominently before us, but neither the time at my disposal nor the purport of this address will allow me to do more than call your attention to some of the more striking results of their investigations.

By far the most frequent mode of multiplication among cells shows itself in a spontaneous division of the protoplasm into two separate portions, which then become independent of one another, so that instead of the single parent cell two new ones have made their appearance. In this process the nucleus usually takes an important part. Strasburger has studied it with great care in certain plant-cells, such as the so-called "corpuscula" or "secondary embryo-sacs" of the Coniferæ and the cells of Spirogyra; and has further shown a close correspondence between cell division in animals and that in plants.

It may be generally stated as the results of his observations on the corpuscula of the *Coniferæ*, that the nucleus of the cell about to divide assumes a spindle-shape, and at the same time presents a peculiar striated differentiation, as if it were composed of parallel filaments reaching from end to end of the spindle. These filaments become thickened in the middle, and there form by the approximation of the thickened portions a transverse plate of protoplasm (the "nucleus-plate"). This soon splits into two halves, which recede from one another toward the poles of the spindle, traveling in this course along the filaments, which remain continuous from end to end. When arrived near the poles they form there two new nuclei, still connected with one another by the intervening portion of the spindle.

In the equator of this intervening portion there is now formed in a similar way a second plate of protoplasm (the "cell-plate"), which, extending to the walls of the dividing cell, cuts the whole protoplasm into two halves, each half containing one of the newly-formed nuclei. This partition plate is at first single, but it soon splits into two laminæ, which become the apposed bounding surfaces of the two protoplasm masses into which the mother cell has been divided. A wall of cellulose is then all at once secerted between them, and the two daughter cells are complete.

It sometimes happens in the generation of cells that a young brood of cells arises from the parent cell by what is called "free-cell formation." In this only a part of the protoplasm of the mother cell is used up in the production of the offspring. It is seen chiefly in the formation of the spores of the lower plants, in the first foundation of the embryo in the higher, and in the formation of the endosperm—a

cellular mass which serves as the first nutriment for the embryo—in the seeds of most Phanerogams. The formation of the endosperm has been carefully studied by Strasburger in the embyro-sac of the kidney-bean, and may serve as an example of the process of free-cell formation. The embryo-sac is morphologically a large cell with its protoplasm, nucleus, and cellulose wall, while the endosperm which arises within it is composed of a multitude of minute cells united into a tissue. The formation of the endosperm is preceded by the dissolution and disappearance of the nucleus of the embryo-sac, and then in the midst of the protoplasm of the sac several new nuclei make their appearance. Around each of these as a center the protoplasm of the mother cell is seen to have become differentiated in the form of a clear spherule, and we have thus corresponding to each of the new nuclei a young naked cell, which soon secretes over its surface a membrane of cellulose. The new cells, when once formed, multiply by division, press one on the other, and so combining into a cellular mass, constitute the completed endosperm.

Related to the formation of new cells, whether by division or by free-cell formation, is another very interesting phenomenon of living protoplasm known as "rejuvenescence." In this the whole protoplasm of a cell, by a new arrangement of its parts, assumes a new shape and acquires new properties. It then abandons its cellulose chamber, and enters on a new and independent life in the surrounding medium.

A good example of this is afforded by the formation of swarm-spores in *Œdogonium*, one of the fresh-water algæ. Here the whole of the protoplasm of an adult cell contracts, and by the expulsion of its cell-sap changes from a cylindrical to a globular shape. Then one spot becomes clear, and a pencil of vibratile cilia here shows itself. The cellulose wall which had hitherto confined it now becomes ruptured, and the protoplasmic sphere, endowed with new faculties of development and with powers of active locomotion, escapes as a swarm-spore, which, after enjoying for a time the free life of an animal, comes to rest, and develops itself into a new plant.

The beautiful researches which have within the last few years been made by the observers already mentioned, on the division of animal cells, show how close is the agreement between plants and animals in all the leading phenomena of cell-division, and afford one more proof of the essential unity of the two great organic kingdoms.

There is one form of cell which, in its relation to the organic world, possesses a significance beyond that of every other, namely, the egg. As already stated, the egg is, wherever it occurs, a typical cell, consisting essentially of a globule of protoplasm enveloping a nucleus (the "germinal vesicle"), and with one or more nucleoli (the "germinal spots") in the interior of the nucleus. This cell, distinguishable by no tangible characters from thousands of other cells, is nevertheless destined to run through a definite series of developmental changes,

which have as their end the building up of an organism like that to which the egg owes its origin.

It is obvious that such complex organisms as thus result—composed, it may be, of countless millions of cells—can be derived from the simple egg-cell only by a process of cell-multiplication. The birth of new cells derived from the primary cell or egg thus lies as the basis of embryonic development. It is here that the phenomena of cell-multiplication in the animal kingdom can in general be most satisfactorily observed, and the greater number of recent researches into the nature of these phenomena, have found their most fertile field in the early periods of the development of the egg.

A discussion of the still earlier changes which the egg undergoes in order to bring it into the condition in which cell-multiplication may be possible, would, however full of interest, be here out of place; and I shall therefore confine myself to the first moments of actual development—to what is called "the cleavage of the egg"—which is nothing more than a multiplication of the egg-cell by repeated division. I shall further confine myself to an account of this phenomenon as presented in typical cases, leaving out of consideration certain modifications which would only complicate and obscure our picture.

The egg, notwithstanding the preliminary changes to which I have alluded, is still at the commencement of development a true cell. It has its protoplasm and its nucleus, and it is, as a rule, enveloped in a delicate membrane. The protoplasm forms what is known as the vitellus, or yolk, and the surrounding membrane is called the "vitellary membrane." The division which is now about to take place in it is introduced by a change of form in the nucleus. This becomes elongated, and assumes the shape of a spindle, similar to what we have already seen in the cell-division of plants. On each pole of the spindle transparent protoplasm collects, forming here a clear spherical area.

At this time a very striking and characteristic phenomenon is witnessed in the egg. Each pole of the spindle has become the center of a system of rays which stream out in all directions into the surrounding protoplasm. The protoplasm thus shows, enveloped in its mass, two sun-like figures, whose centers are connected with one another by the spindle-shaped nucleus. To this, with the sun-like rays streaming from its poles, Auerbach gives the name of "Karyolitic figure," suggested by its connection with the breaking up of the original nucleus, to which our attention must next be directed.

A phenomenon similar to one we have already seen in cell-division among plants now shows itself. The nucleus becomes broken up into a number of filaments, which lie together in a bundle, each filament stretching from pole to pole of the spindle. Exactly in its central point every filament shows a knot-like enlargement, and from the close approximation of the knots there results a thick zone of protoplasm in the equator of the spindle. Each knot soon divides into two halves,

and each half recedes from the equator and travels along the filament toward its extremity. When arrived at the poles of the spindle each set of half knots becomes fused together into a globular body, while the intervening portion of the spindle, becoming torn up, and gradually drawn into the substance of the two globular masses, finally disappears. And now, instead of the single fusiform nucleus, whose changes we have been tracing, we have two new globular nuclei, each occupying the place of one of its poles, and formed at its expense.* The egg now begins to divide along a plane at right angles to a line connecting the two nuclei. The division takes place without the formation of a cell-plate such as we saw in the division of the plant-cell, and is introduced by a constriction of its protoplasm, which commences at the circumference just within the vitelline membrane, and extending toward the center, divides the whole mass of protoplasm into two halves, each including within it one of the new nuclei. Thus the simple cell which constituted the condition of the egg at the commencement of development becomes divided into two similar cells. This forms the first stage of cleavage. Each of these two young cells divides in its turn in a direction at right angles to the first division-plane, while by continued repetition of the same act the whole of the protoplasm or yolk becomes broken up into a vast multitude of cells, and the unicellular organism—the egg, with which we began our history—has become converted into an organism composed of many thousands of cells. This is one of the most widely distributed phenomena of the organic world. It is called "the cleavage of the egg," and consists essentially in the production, by division, of successive broods of cells from a single ancestral cell—the egg.

It is no part of my purpose to carry on the phenomena of development further than this. Such of my hearers as may desire to become

* Though none of the above-mentioned observers, to whom we owe our knowledge of the phenomena here described, seem to have thought of connecting the fibrous condition assumed by the spindle with any special structure of the quiescent nucleus, it is highly probable that it consists in a rearrangement of fibers already present. That this is really the case is borne out by the observations of Schleicher on the division of cartilage-cells. ("Die Knorpelzelltheilung," "Arch. für mikr. Anat.," Band xvi., Heft 2, 1878.) From these it would appear that, in the division of cartilage-cells, the investing membrane of the nucleus first becomes torn up, and then the filaments, rodlets, and granules, which, according to him, form its body, enter into a state of intense motor activity, and may be seen arranging themselves into star-like, or wreath-like, or irregular figures, while the whole nucleus, now deprived of its membrane, may wander about the cell, traveling toward one of its poles, and then toward the other; or it may at one time contract, and then again dilate, to such an extent as nearly to fill the entire cell. To this nuclear activity Schleicher applies the term "Karyokinesis." It results in a nearly parallel arrangement of the nuclear filaments. Then these converge at their extremities and become more widely separated in the middle, so as to give to the nucleus the form of a spindle. The filaments then become fused together at each pole of the spindle, so as to form the two new nuclei, which are at first nearly homogeneous, but which afterward become broken up into their component filaments, rods, and granules.

acquainted with the further history of the embryo, I would refer to the excellent address delivered two years ago at the Plymouth meeting of the Association by one of my predecessors in this chair—Professor Allen Thompson.

That protoplasm, however, may present a phenomenon the reverse of that in which a simple cell becomes multiplied into many, is shown by a phenomenon already referred to—the production of plasmodia in the *Myxomycetæ* by the fusion into one another of cells originally distinct.

The genus *Myriothela* will afford another example in which the formation of plasmodia becomes introduced into the cycle of development. The primitive eggs are here, as elsewhere, true cells with nucleolated nuclei, but without any boundary membrane. They are formed in considerable numbers, but remain only for a short time separate and distinct. After this they begin to exhibit amœboid changes of shape, project pseudopodial prolongations which coalesce with those of others in their vicinity, and, finally, a multitude of these primitive ova become fused together into a common plasmodium, in which, as in the simple egg-cell of other animals, the phenomena of development take place.

In many of the lower plants a very similar coalescence is known to take place between the protoplasmic bodies of separate cells, and constitutes the phenomenon of conjugation. *Spirogyra* is a genus of algæ, consisting of long, green threads common in ponds. Every thread is composed of a series of cylindrical chambers of transparent cellulose placed end to end, each containing a sac of protoplasm with a large quantity of cell-sap, and with a green band of chlorophyl wound spirally on its walls. When the threads have attained their full growth they approach one another in pairs, and lie in close proximity, parallel one to the other. A communication is then established by means of short connecting-tubes between the chambers of adjacent filaments, and across the channel thus formed the whole of the protoplasm of one of the conjugating chambers passes into the cavity of the other, and then immediately fuses with the protoplasm it finds there. The single mass thus formed shapes itself into a solid oval body, known as a "zygospore." This now frees itself from the filament, secretes over its naked surface a new wall of cellulose, and, when placed in the conditions necessary for its development, attaches itself by one end, and then, by repeated acts of cell-division, grows into a many-celled filament like those in which it originated.

The formation of plasmodia, regarded as a coalescence and absolute fusion into one another of separate, naked masses of protoplasm, is a phenomenon of great significance. It is highly probable that, notwithstanding the complete loss of individuality in the combining elements, such differences as may have been present in these will always find themselves expressed in the properties of the resulting plas-

modia—a fact of great importance in its bearing on the phenomena of inheritance. Recent researches, indeed, render it almost certain that fertilization, whether in the animal or the vegetable kingdom, consists essentially in the coalescence and consequent loss of individuality of the protoplasmic contents of two cells.

In by far the greater number of plants the protoplasm of most of the cells which are exposed to the sunlight undergoes a curious and important differentiation, part of it becoming separated from the remainder in the form usually of green granules, known as chlorophyl-granules. The chlorophyl-granules thus consist of true protoplasm, their color being due to the presence of a green coloring matter, which may be extracted, leaving behind the colorless protoplasmic base.

The coloring matter of chlorophyl presents under the spectroscope a very characteristic spectrum. For our knowledge of its optical properties, on which time will not now permit me to dwell, we are mainly indebted to the researches of your townsman, Dr. Sorby, who has made these the subject of a series of elaborate investigations, which have contributed largely to the advancement of an important department of physical science.

That the chlorophyl is a living substance, like the uncolored protoplasm of the cell, is sufficiently obvious. When once formed, the chlorophyl-granule may grow by intussusception of nutriment to many times its original size, and may multiply itself by division.

To the presence of chlorophyl is due one of the most striking aspects of external nature—the green color of the vegetation which clothes the surface of the earth : and with its formation is introduced a function of fundamental importance in the economy of plants, for it is on the cells which contain this substance that devolves the faculty of decomposing carbonic acid. On this depends the assimilation of plants, a process which becomes manifest externally by the exhalation of oxygen. Now, it is under the influence of light on the chlorophyl-containing cell that this evolution of oxygen is brought about. The recent observations of Draper and of Pfeffer have shown that in this action the solar spectrum is not equally effective in all its parts ; that the yellow and least refrangible rays are those which act with most intensity ; that the violent and other highly refrangible rays of the visible spectrum take but a very subordinate part in assimilation ; and that the invisible rays which lie beyond the violet are totally inoperative.

In almost every grain of chlorophyl one or more starch-granules may be seen. This starch is chemically isomeric with the cellulose cell-wall, with woody fiber, and other hard parts of plants, and is one of the most important products of assimilation. When plants whose chlorophyl contains starch are left for a sufficient time in darkness, the starch is absorbed and completely disappears ; but when they

are restored to the light the starch reappears in the chlorophyl of the cells.

With this dependence of assimilation on the presence of chlorophyl a new physiological division of labor is introduced into the life of plants. In the higher plants, while the work of assimilation is allocated to the chlorophyl-containing cells, that of cell division and growth devolves on another set of cells, which, lying deeper in the plant, are removed from the direct action of light, and in which chlorophyl is therefore never produced. In certain lower plants, in consequence of their simplicity of structure and the fact that all the cells are equally exposed to the influence of light, this physiological division of labor shows itself in a somewhat different fashion. Thus in some of the simple green algæ, such as *Spirogyra* and *Hydrodictyon*, assimilation takes place as in other cases during the day, while their cell division and growth takes place chiefly, if not exclusively, at night. Strasburger, in his remarkable observations on cell-divisions in *Spirogyra*, was obliged to adopt an artificial device in order to compel the *Spirogyra* to postpone the division of its cells to the morning.

Here the functions of assimilation and growth devolve on one and the same cell, but, while one of these functions is exercised only during the day, the time for the other is the night. It seems impossible for the same cell at the same time to exercise both functions, and these are here accordingly divided between different periods of the twenty-four hours.

The action of chlorophyl in bringing about the decomposition of carbonic acid is not, as was recently believed, absolutely confined to plants. In some of the lower animals, such as *Stentor* and other infusoria, the Green Hydra, and certain green planariæ and other worms, chlorophyl is differentiated in their protoplasm, and probably always acts here under the influence of light exactly as in plants.

Indeed, it has been proved* by some recent researches of Mr. Geddes, that the green planarias when placed in water and exposed to the sunlight give out bubbles of gas which contain from forty-four to fifty-five per cent. of oxygen. Mr. Geddes has further shown that these animals contain granules of starch in their tissues, and in this fact we have another striking point of resemblance between them and plants.

A similar approximation of the two organic kingdoms has been shown by the beautiful researches of Mr. Darwin—confirmed and extended by his son, Mr. Francis Darwin—on Drosera and other so-called carnivorous plants. These researches, as is now well known, have shown that in all carnivorous plants there is a mechanism fitted for the capture of living prey, and that the animal matter of the prey is absorbed by the plant after having been digested by a secretion which acts like the gastric juice of animals.

* "Sur la Fonction de la Chlorophyll dans les Planaires vertes," "Comptes Rendus," December, 1878.

Again, Nägeli has recently shown * that the cell of the yeast-fungus contains about two per cent. of peptine, a substance hitherto known only as a product of the digestion of azotized matter by animals.

Indeed, all recent research has been bringing out in a more and more decisive manner the fact that there is no dualism in life—that the life of the animal and the life of the plant are, like their protoplasm, in all essential points identical.

But there is, perhaps, nothing which shows more strikingly the identity of the protoplasm in plants and animals, and the absence of any deep-pervading difference between the life of the animal and that of the plant, than the fact that plants may be placed, just like animals, under the influence of anæsthetics.

When the vapor of chloroform or of ether is inhaled by the human subject, it passes into the lungs, where it is absorbed by the blood, and thence carried by the circulation to all the tissues of the body. The first to be affected by it is the delicate nervous element of the brain, and loss of consciousness is the result. If the action of the anæsthetic be continued, all the other tissues are in their turn attacked by it and their irritability arrested. A set of phenomena entirely parallel to these may be presented by plants.

We owe to Claude Bernard a series of interesting and most instructive experiments on the action of ether and chloroform on plants. He exposed to the vapor of ether a healthy and vigorous sensitive-plant, by confining it under a bell-glass into which he introduced a sponge filled with ether. At the end of half an hour the plant was in a state of anæsthesia. All its leaflets remained fully extended, but they showed no tendency to shrink when touched. It was then withdrawn from the influence of the ether, when it gradually recovered its irritability, and finally responded, as before, to the touch.

It is obvious that the irritability of the protoplasm was here arrested by the anæsthetic, so that the plant became unable to give a response to the action of an external stimulus.

It is not, however, the irritability of the protoplasm of only the motor elements of plants that anæsthetics are capable of arresting. These may act also on the protoplasm of those cells whose function lies in chemical synthesis, such as is manifested in the phenomena of the germination of the seed and in nutrition generally, and Claude Bernard has shown that germination is suspended by the action of ether or chloroform.

Seeds of cress, a plant whose germination is very rapid, were placed in conditions favorable to a speedy germination, and while thus placed were exposed to the vapor of ether. The germination, which would otherwise have shown itself by the next day, was arrested. For five or six days the seeds were kept under the influence of the ether, and

* "Ueber die chemische Zusammensetzung der Hefe," "Sitzungsbericht der math. phys. Classe der k.k. Akad. der Wissens. zu München," 1878.

showed during this time no disposition to germinate. They were not killed, however, they only slept; for, on the substitution of common air for the etherized air with which they had been surrounded, germination at once set in and proceeded with activity.

Experiments were also made on that function of plants by which they absorb carbonic acid and exhale oxygen, and which, as we have already seen, is carried on through the agency of the green protoplasm or chlorophyl, under the influence of light—a function which is commonly, but erroneously, called the respiration of plants.

Aquatic plants afford the most convenient subjects for such experiments. If one of these be placed in a jar of water holding ether or chloroform in solution, and a bell-glass be placed over the submerged plant, we shall find that the plant no longer absorbs carbonic acid or emits oxygen. It remains, however, quite green and healthy. In order to awaken the plant, it is only necessary to place it in non-etherized water, when it will begin once more to absorb carbonic acid, and exhale oxygen under the influence of sunlight.

The same great physiologist has also investigated the action of anæsthetics on fermentation. It is well known that alcoholic fermentation is due to the presence of a minute fungus, the yeast-fungus, the living protoplasm of whose cells has the property of separating solutions of sugar into alcohol, which remains in the liquid, and carbonic acid, which escapes into the air.

Now, if the yeast-plant be placed along with sugar in etherized water, it will no longer act as a ferment. It is anæsthesiated, and can not respond to the stimulus which, under ordinary circumstances, it would find in the presence of the sugar. If, now, it be placed on a filter, and the ether washed completely away, it will, on restoration to a saccharine liquid, soon resume its duty of separating the sugar into alcohol and carbonic acid.

Claude Bernard has further called attention to a very significant fact which is observable in this experiment. While the proper alcoholic fermentation is entirely arrested by the etherization of the yeast-plant, there still goes on in the saccharine solution a curious chemical change, the cane-sugar of the solution being converted into grape-sugar, a substance identical in its chemical composition with the cane-sugar, but different in its molecular constitution. Now, it is well known from the researches of Berthelot that this conversion of cane-sugar into grape-sugar is due to a peculiar inversive ferment, which, while it accompanies the living yeast-plant, is itself soluble and destitute of life. Indeed, it has been shown that, in its natural conditions, the yeast-fungus is unable of itself to assimilate cane-sugar, and that, in order that this may be brought into a state fitted for the nutrition of the fungus, it must be first digested and converted into grape-sugar, exactly as happens in our own digestive organs. To quote Claude Bernard's graphic account: "The fungus ferment has thus beside it

in the same yeast a sort of servant given by Nature to effect this digestion. The servant is the unorganized inversive ferment. This ferment is soluble, and, as it is not a plant, but an unorganized body destitute of sensibility, it has not gone to sleep under the action of the ether, and thus continues to fulfill its task."

In the experiment already recorded on the germination of seeds the interest is by no means confined to that which attaches itself to the arrest of the organizing functions of the seed, those namely which manifest themselves in the development of the radicle, and plumule, and other organs of the young plant. Another phenomenon of great significance becomes at the same time apparent: the anæsthetic exerts no action on the concomitant chemical phenomena which in germinating seeds show themselves in the transformation of starch into sugar under the influence of diastase (a soluble and non-living ferment which also exists in the seed), and the absorption of oxygen with the exhalation of carbonic acid. These go on as usual, the anæsthesiated seed continuing to respire, as proved by the accumulation of carbonic acid in the surrounding air. The presence of the carbonic acid was rendered evident by placing in the same vessel with the seeds which were the object of the experiment a solution of barytes, when the carbonate became precipitated from the solution in quantity equal to that produced in a similar experiment with seeds germinating in unetherized air.

So, also, in the experiment which proves that the faculty possessed by the chlorophyllian cells of absorbing carbonic acid and exhaling oxygen under the influence of light may be arrested by anæsthetics, it could be seen that the plant, while in a state of anæsthesia, continued to respire in the manner of animals; that is, it continued to absorb oxygen and exhale carbonic acid. This is the true respiratory function which was previously masked by the predominant function of assimilation, which devolves on the green cells of plants, and which manifests itself under the influence of light in the absorption of carbonic acid and the exhalation of oxygen.

It must not, however, be supposed that the respiration of plants is entirely independent of life. The conditions which bring the oxygen of the air and the combustible matter of the respiring plant into such relations as may allow them to act on one another are still under its control, and we must conclude that in Claude Bernard's experiment the anæsthesia had not been carried so far as to arrest such properties of the living tissues as are needed for this.

The quite recent researches of Schützenberger, who has investigated the process of respiration as it takes place in the cell of the yeast-fungus, have shown that vitality is a factor in this process. He has shown that fresh yeast, placed in water, breathes like an aquatic animal, disengaging carbonic acid, and causing the oxygen contained in the water to disappear. That this phenomenon is a function of the

living cell is proved by the fact that, if the yeast be first heated to 60° C. and then placed in the oxygenated water, the quantity of oxygen in the water remains unchanged; in other words, the yeast ceases to breathe.

Schützenberger has further shown that light exerts no influence on the respiration of the yeast-cell—that the absorption of oxygen by the cell takes place in the dark exactly as in sunlight. On the other hand, the influence of temperature is well marked. Respiration is almost entirely arrested at temperatures below 10° C., it reaches its maximum at about 40° C., while at 60° C. it again ceases.

All this proves that the respiration of living beings is identical, whether manifested in the plant or in the animal. It is essentially a destructive phenomenon—as much so as the burning of a piece of charcoal in the open air, and, like it, is characterized by the disappearance of oxygen and the formation of carbonic acid.

One of the most valuable results of the recent careful application of the experimental method of research to the life-phenomena of plants is thus the complete demolition of the supposed antagonism between respiration in plants and that in animals.

I have thus endeavored to give you in a few broad outlines a sketch of the nature and properties of one special modification of matter, which will yield to none other in the interest which attaches to its study, and in the importance of the part allocated to it in the economy of nature. Did the occasion permit, I might have entered into many details which I have left untouched; but enough has been said to convince you that in protoplasm we find the only form of matter in which life can manifest itself; and that, though the outer conditions of life—heat, air, water, food—may all be present, protoplasm would still be needed, in order that these conditions may be utilized; in order that the energy of lifeless nature may be converted into that of the countless multitudes of animal and vegetable forms which dwell upon the surface of the earth or people the great depths of its seas.

We are thus led to the conception of an essential unity in the two great kingdoms of organic nature—a structural unity, in the fact that every living being has protoplasm as the essential matter of every living element of its structure; and a physiological unity, in the universal attribute of irritability which has its seat in this same protoplasm, and is the prime mover of every phenomenon of life.

We have seen how little mere form has to do with the essential properties of protoplasm. This may shape itself into cells, and the cells may combine into organs in ever-increasing complexity, and protoplasm-force may be thus intensified, and, by the mechanism of organization, turned to the best possible account; but we must still go back to protoplasm as a naked, formless plasma if we would find—freed from all non-essential complications—the agent to which has

been assigned the duty of building up structure and of transforming the energy of lifeless matter into that of living.

To suppose, however, that all protoplasm is identical where no difference cognizable by any means at our disposal can be detected would be an error. Of two particles of protoplasm, between which we may defy all the power of the microscope, all the resources of the laboratory, to detect a difference, one can develop only to a jelly-fish, the other only to a man, and one conclusion alone is here possible—that deep within them there must be a fundamental difference which thus determines their inevitable destiny, but of which we know nothing, and can assert nothing beyond the statement that it must depend on their hidden molecular constitution.

In the molecular condition of protoplasm there is probably as much complexity as in the disposition of organs in the most highly differentiated organisms; and between two masses of protoplasm indistinguishable from one another there may be as much molecular difference as there is between the form and arrangement of organs in the most widely separated animals or plants.

Herein lies the many-sidedness of protoplasm; herein lies its significance as the basis of all morphological expression, as the agent of all physiological work, while in all this there must be an adaptiveness to purpose as great as any claimed for the most complicated organism.

From the facts which have been now brought to your notice there is but one legitimate conclusion—that life is a property of protoplasm. In this assertion there is nothing that need startle us. The essential phenomena of living beings are not so widely separated from the phenomena of lifeless matter as to render it impossible to recognize an analogy between them; for even irritability, the one grand character of all living beings, is not more difficult to be conceived of as a property of matter than the physical phenomena of radial energy.

It is quite true that between lifeless and living matter there is a vast difference, a difference greater far than any which can be found between the most diverse manifestations of lifeless matter. Though the refined synthesis of modern chemistry may have succeeded in forming a few principles which until lately had been deemed the proper product of vitality, the fact still remains that no one has ever yet built up one particle of living matter out of lifeless elements—that every living creature, from the simplest dweller on the confines of organization up to the highest and most complex organism, has its origin in preëxistent living matter—that the protoplasm of to-day is but the continuation of the protoplasm of other ages, handed down to us through periods of indefinable and indeterminable time.

Yet with all this, vast as the differences may be, there is nothing which precludes a comparison of the properties of living matter with those of lifeless.

When, however, we say that life is a property of protoplasm, we

assert as much as we are justified in doing. Here we stand upon the boundary between life in its proper conception, as a group of phenomena having irritability as their common bond, and that other and higher group of phenomena which we designate as consciousness or thought, and which, however intimately connected with those of life, are yet essentially distinct from them.

When the heart of a recently killed frog is separated from its body and touched with the point of a needle, it begins to beat under the excitation of the stimulus, and we believe ourselves justified in referring the contraction of the cardiac fibers to the irritability of their protoplasm as its proper cause. We see in it a remarkable phenomenon, but one nevertheless in which we can see unmistakable analogies with phenomena purely physical. There is no greater difficulty in conceiving of contractility as a property of protoplasm than there is of conceiving of attraction as a property of the magnet.

When a thought passes through the mind, it is associated, as we have now abundant reason for believing, with some change in the protoplasm of the cerebral cells. Are we, therefore, justified in regarding thought as a property of the protoplasm of these cells, in the sense in which we regard muscular contraction as a property of the protoplasm of muscle, or is it really a property residing in something far different, but which may yet need for its manifestation the activity of cerebral protoplasm?

If we could see any analogy between thought and any one of the admitted phenomena of matter, we should be justified in accepting the first of these conclusions as the simplest, and as affording an hypothesis most in accordance with the comprehensiveness of natural laws; but between thought and the physical phenomena of matter there is not only no analogy, but there is no conceivable analogy; and the obvious and continuous path which we have hitherto followed up in our reasonings from the phenomena of lifeless matter through those of living matter here comes suddenly to an end. The chasm between unconscious life and thought is deep and impassable, and no transitional phenomena can be found by which as by a bridge we may span it over; for even from irritability, to which, on a superficial view, consciousness may seem related, it is as absolutely distinct as it is from any of the ordinary phenomena of matter.

It has been argued that because physiological activity must be a property of every living cell, psychical activity must be equally so, and the language of the metaphysician has been carried into biology, and the "cell-soul" spoken of as a conception inseparable from that of life.

That psychical phenomena, however, characterized as they essentially are by consciousness, are not necessarily coextensive with those of life, there can not be a doubt. How far back in the scale of life consciousness may exist we have as yet no means of determining, nor

is it necessary for our argument that we should. Certain it is that many things, to all appearance the result of volition, are capable of being explained as absolutely unconscious acts ; and when the swimming swarm-spore of an alga avoids collision, and, by a reversal of the stroke of its cilia, backs from an obstacle lying in its course, there is almost certainly in all this nothing but a purely unconscious act. It is but a case in which we find expressed the great law of the adaptation of living beings to the conditions which surround them. The irritability of the protoplasm of the ciliated spore responding to an external stimulus sets in motion a mechanism derived by inheritance from its ancestors, and whose parts are correlated to a common end—the preservation of the individual.

But even admitting that every living cell were a conscious and thinking being, are we therefore justified in asserting that its consciousness, like its irritability, is a property of the matter of which it is composed ? The sole argument on which this view is made to rest is that from analogy. It is argued that because the life-phenomena, which are invariably found in the cell, must be regarded as a property of the cell, the phenomena of consciousness by which they are accompanied must be also so regarded. The weak point in the argument is the absence of all analogy between the things compared, and, as the conclusion rests solely on the argument from analogy, the two must fall to the ground together.

In a lecture * to which I once had the pleasure of listening—a lecture characterized no less by lucid exposition than by the fascinating form in which its facts were presented to the hearers—Professor Huxley argues that no difference, however great, between the phenomena of living matter and those of the lifeless elements of which this matter is composed should militate against our attributing to protoplasm the phenomena of life as properties essentially inherent in it ; since we know that the result of a chemical combination of physical elements may exhibit physical properties totally different from those of the elements combined ; the physical phenomena presented by water, for example, having no resemblance to those of its combining elements, oxygen and hydrogen.

I believe that Professor Huxley intended to apply this argument only to the phenomena of life in the stricter sense of the word. As such it is conclusive. But when it is pushed further, and extended to the phenomena of consciousness, it loses all its force. The analogy, perfectly valid in the former case, here fails. The properties of the chemical compound are like those of its components, still physical properties. They come within the wide category of the universally accepted properties of matter, while those of consciousness belong to a category absolutely distinct—one which presents not a trace of a connection with any of those which physicists have agreed in assign-

* "The Physical Basis of Life" (see "Essays and Reviews," by T. H. Huxley).

ing to matter as its proper characteristics. The argument thus breaks down, for its force depends on analogy alone, and here all analogy vanishes.

That consciousness is never manifested except in the presence of cerebral matter or of something like it, there can not be a question ; but this is a very different thing from its being a property of such matter in the sense in which polarity is a property of the magnet, or irritability of protoplasm. The generation of the rays which lie invisible beyond the violet in the spectrum of the sun can not be regarded as a property of the medium which by changing their refrangibility can alone render them apparent.

I know that there is a special charm in those broad generalizations which would refer many very different phenomena to a common source. But in this very charm there is undoubtedly a danger, and we must be all the more careful lest it should exert an influence in arresting the progress of truth, just as at an earlier period traditional beliefs exerted an authority from which the mind but slowly and with difficulty succeeded in emancipating itself.

But have we, it may be asked, made in all this one step forward toward an explanation of the phenomena of consciousness or the discovery of its source ? Assuredly not. The power of conceiving of a substance different from that of matter is still beyond the limits of human intelligence, and the physical or objective conditions which are the concomitants of thought are the only ones of which it is possible to know anything, and the only ones whose study is of value.

We are not, however, on that account forced to the conclusion that there is nothing in the universe but matter and force. The simplest physical law is absolutely inconceivable by the highest of the brutes, and no one would be justified in assuming that man had already attained the limit of his powers. Whatever may be that mysterious bond which connects organization with psychical endowments, the one grand fact—a fact of inestimable importance—stands out clear and freed from all obscurity and doubt, that from the first dawn of intelligence there is with every advance in organization a corresponding advance in mind. Mind as well as body is thus traveling onward through higher and still higher phases ; the great law of evolution is shaping the destiny of our race ; and though now we may at most but indicate some weak point in the generalization which would refer consciousness as well as life to a common material source, who can say that in the far-off future there may not yet be evolved other and higher faculties from which light may stream in upon the darkness, and reveal to man the great mystery of thought ?

JOHN STUART MILL.

By ALEXANDER BAIN, LL. D.,
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III.

MY acquaintance with Mill dates from 1839, when I was a student at Marischal College, Aberdeen. In the winter of 1838–'39, John Robertson, who was then assisting in the Review, paid a short visit to his native city. I had known him when I was a child, but had not seen him for years. He asked me to meet him, and entered into free conversation about his doings in London, and about my pursuits and prospects. He gave me both advice and encouragement, and spoke a good deal about Mill, whom I had never heard of, although I may have known something of his father. On returning to London, Robertson mentioned my name to Mill. In the summer of 1839 I wrote a criticism of some points in Herschel's "Discourse on Natural Philosophy," a book that had long fascinated me, as it had done so many others. I thought Herschel occasionally weak in his metaphysics, and directed my criticism to some of those weaknesses. Robertson showed Mill this paper. He spoke favorably of the effort, but remarked to me afterward that the criticism was too severe, and that the book "always seemed to him to have the characters of a first crude attempt of a clever and instructed man in a province new to him."

In 1840 I took my M. A. degree, and began to write for periodicals. Mill had just parted with the "London and Westminster": but through Robertson, I got my first published article admitted into the "Westminster" for September; an exposition of the two scientific novelties—the electrotype and daguerreotype. In July, 1841, was published a second article entitled "The Properties of Matter," to which I owed the first notice taken of me by Mr. Grote. Both these articles did me good with Mill. In the same autumn (1841) Robertson, who was now very much at sea himself, came down to Aberdeen, and made a long stay; during which I had abundant talk with him, my early friend David Masson being also of the party. Robertson occasionally wrote to Mill, and at last incited me to write to him. I scarcely remember anything of the terms of the letter, but I have preserved his reply, dated 21st September, 1841. After my first meeting with Robertson, nearly three years previous, I assiduously perused the back numbers of the "London" and "London and Westminster" Reviews, as well as each new number as it appeared, whereby I became thoroughly familiarized with Mill's ideas, and was thus able to exchange ideas with him on his own subjects. I was engaged for the succeed-

ing winter to teach the class of moral philosophy in Marischal College, as substitute for the Professor; and his letter is chiefly a comment upon this fact. Notwithstanding that he was then intently occupied in finishing his "Logic" for the press, he wrote me several other letters in the course of the winter. In the one immediately following (October 15th), he made mention of Comte, in these terms: "Have you ever looked into Comte's 'Cours de Philosophie Positive'? He makes some mistakes, but on the whole I think it very nearly the grandest work of this age." From the remaining letters, I can gather that I had written him a good deal upon Whewell's writings, as well as on Herschel, and on his own coming book. Among other things, he sketched out for me a course of reading on political and historical philosophy. He also criticised in detail the strong and weak points of an article published by me in the "Westminster" in January, 1842, with the somewhat misleading title—"Toys."

As soon as the Aberdeen winter session was over, in the middle of April, 1842, I went to London, and remained there five months. The day after arriving I walked down to the India House with Robertson, and realized my dream of meeting Mill in person. I am not likely to forget the impression he made upon me as he stood by his desk, with his face turned to the door as we entered. His tall, slim figure, his youthful face and bald head, fair hair and ruddy complexion, and the twitching of his eyebrow when he spoke, first arrested the attention: then the vivacity of his manner, his thin voice approaching to sharpness, but with nothing shrill or painful about it, his comely features and sweet expression—would have all remained in my memory, though I had never seen him again. To complete the picture, I should add his dress, which was constant—a black dress-suit, with silk necktie. Many years after that he changed his dress-coat for a surtout; but black cloth was his choice to the end.

My opportunities of conversation with him for these five months consisted in going down to the India House twice a week at four o'clock, and walking with him a good part of his way to Kensington Square, where his mother and family lived. I also spent occasional evenings at the house, where I met other friends of his—G. H. Lewes being a frequent visitor. I may be said to have traveled over a good part of his mind that summer: although he did not then give me his full confidence in many things that I came to know afterward. I had a very full acquaintance with his views on philosophy and politics, as well as a complete appreciation of his whole manner of thinking.

His "Logic" was finished and ready for press; he had intended that it should be out in April of that year (1842). He had submitted it the previous winter to Mr. John Murray, who kept it for some time, and then declined it, so that it could not be brought out that season. He then submitted it to J. W. Parker, by whom it was

eagerly accepted.* I do not remember the date of Parker's acceptance, but the book had not begun to go to press in the summer months; the printing actually took place in the following winter. One of the first results of our conversations was that he gave me the manuscript to peruse. During my stay I read and discussed with him the whole of it.

The impression made upon me by the work was, as may be supposed, very profound. I knew pretty well the works that could be ranked as its precursors in inductive logic, but the difference between it and them was obviously vast. The general impression at first overpowered my critical faculties; and it was some time before I could begin to pick holes. I remember, among the first of my criticisms, remarking on the chapter on "Things denoted by Names" as not being very intelligible; I had at the same time a difficulty in seeing its place in the scheme, although I did not press this objection. The effect was that he revised the chapter, and introduced the subordinate headings, which very much lightened the burden of its natural abstruseness.

The main defect of the work, however, was in the experimental examples. I soon saw, and he felt, as much as I did, that these were too few and not unfrequently incorrect. It was on this point that I was able to render the greatest service. Circumstances had made me tolerably familiar with the experimental physics, chemistry, and physiology of that day, and I set to work to gather examples from all available sources. Liebig's books on the application of chemistry had then just appeared, and contained many new and striking facts and reasonings, which we endeavored to turn to account: although at the present day some of those inductions of his have lost their repute. An Aberdeen lecturer on chemistry, the late Dr. John Shier (chemist to the colony of Demerara) went carefully over with me all the chemical examples, and struck out various erroneous statements. I had recently made a study of Faraday's very stiff papers on electricity, and from these I extracted one generalization, somewhat modified by myself, and this Mill prized very highly; nevertheless, it was afterward carped at by Whewell, as going beyond what Faraday would have allowed. One way or other, I gave him a large stock of examples to choose from, as he revised the third book for the press. The difficulty that was most felt was to get good examples of the *purely experimental* methods. He had availed himself of the famous research on dew adduced by Herschel. There was hardly to be got any other example so good. For one of his later editions I gave him the example from

* So great a work can sustain even a little anecdote. Parker, in intimating his willingness to publish the book, sent the opinion of his referee, in the writer's own hand, withholding the name. "He forgot," said Mill, "that I had been an editor, and knew the handwriting of nearly every literary man of the day." The referee was Dr. W. Cooke Taylor, who afterward was one of the reviewers of the book.

Brown-Séquard, on the causes of cadaveric rigidity, and also used it in my own book. For the deductive method, and the allied subjects of explanation and empirical and derivative law, the examples that we found were abundant. When, however, I suggested his adopting some from psychology, he steadily, and I believe wisely, resisted; and, if he took any of these, it was in the deductive department.

I was so much struck with the view of induction that regarded it as reasoning from particulars to particulars, that I suggested a further exemplification of it in detail, and he inserted two pages of instances that I gave him. On the last three books I had little to offer. I remember his saying, at a later period, that the fourth book (which I have always regarded as the crude materials of a logic of definition and classification) was made up of a number of subjects that he did not know where to place.

The "Logic" has been about the best attacked book of the time; and the author has in successive editions replied to objections and made extensive amendments. I have had myself full opportunities for expressing both agreements and dissents in regard to all the main points. Yet I could not pretend to say that criticism has been exhausted, or that imperfections and even inconsistencies may not even yet be pointed out. It is long since I was struck with the seeming incompatibility between the definition of logic in the introduction—viz., the science of proof, or evidence—and the double designation in the title—Principles of Evidence and the Methods of Scientific Investigation. Previous writers laid little stress on proof, and Mill took the other extreme and made proof everything. Bacon, Herschel, and Whewell seemed to think that, if we could only make discoveries, the proof would be readily forthcoming—a very natural supposition with men educated mainly in mathematics and physics. Mill, from his familiarity with the moral and political sciences, saw that proof was more important than discovery. But the title, although larger than the definition, is not larger than the work; he did discuss the methods of investigation, as aids to discovery, as well as means of proof; only, he never explained the mutual bearings of the two. Any one that tries will find this not an easy matter.

The sixth book was the outcome of his long study of politics, both practical and theoretical, to which the finishing stroke was given by the help of Auguste Comte. I will return to this presently.

In five months he carried the work through the press, and brought it out in March, 1843. We may form some estimate of the united labor of correcting proof-sheets, often one a day, of reconsidering the new examples that have been suggested, of reading Liebig's two books, and Comte's sixth volume (nearly a thousand pages), and of recasting the concluding chapters. From the moment of publication, the omens were auspicious. Parker's trade-sale was beyond his anticipations, and the book was asked for by unexpected persons, and appeared in

shop-windows where he never thought to see it. Whately spoke handsomely of it, and desired his bookseller to get an additional copy for him, and expose it in the window.

While the work was printing, I prepared from the sheets a review of it, which came out in the "Westminster" in the April number, and was even more laudatory than Mill liked. The first adverse criticism of importance was an article in the autumn number of the "British Critic," of nearly a hundred pages, known to have been written by Mr. W. G. Ward, the ally of Newman and Pusey. It was a most remarkable production, and gave Mill very great satisfaction, all things considered. It was not so much a review of the "Logic" as of Mill altogether. Mr. Ward had followed him through his various articles in the "London and Westminster," and had mastered his modes of thinking in all the great questions; and the present article takes these up along with the "Logic." He expresses a warm interest in Mill himself, remarking, "An inquirer, who bears every mark of a single-minded and earnest pursuit of truth, cheers and relieves the spirits"; a pretty strong innuendo as to the prevailing dispositions of so-called inquirers. He deplores Mill's "miserable moral and religious deficiencies," and says if his "principles be adopted as a full statement of the truth, the whole fabric of Christian theology must totter and fall." Accordingly, the article is devoted to counterworking these erroneous tendencies; and the parts chosen for attack are the experience-foundations of the mathematical axioms, the derived view of conscience, and necessity as against free-will. Mr. Ward has continued to uphold his peculiar tenets against the experience-school. He had afterward, as he informs me, a good deal of correspondence with Mill, and once met him. At his instigation, Mill expunged from his second edition an objectionable anecdote.*

Without pursuing further at present the fortunes of the "Logic," I will allude to the connection between Mill and Comte, and to the share that Comte had in shaping Mill's political philosophy. Wheatstone always claimed to be the means of introducing Comte in England. He brought over from Paris the first two volumes of the "Philosophie Positive," after the publication of the second, which was in 1837. It would appear that the first volume, by itself, published in 1830, had fallen dead; notwithstanding that the first two chapters really contained in very clear language, although without expansion, the two great foundations that Comte built upon—the Three Stages and the Hierarchy of the Sciences. Wheatstone mentioned the work to his scientific friends in London, and among others to Brewster, who was then a contributor of scientific articles to the "Edinburgh Re-

* In regard to the "British Critic," he wrote, "I always hailed Puseyism, and predicted that thought would sympathize with thought—though I did not expect to find my own case so striking an example." I was told that he had written several letters in the "Morning Chronicle" in this strain of subtile remark.

view." Comte's volumes struck him at once as a good topic; and he wrote an article on them in the August number for 1838. Any one knowing him would have predicted as the strain of his review an indignant or else contemptuous exposure of the atheism, a fastening on the weak points in his own special subjects, as optics, and a cold recognition of his systematic comprehensiveness. This, however, was to leave out of the account one element—his antipathy to Whewell; sufficiently marked in a review of the "History of the Inductive Sciences" in the previous year. He found with joy a number of observations on hypothesis and other points, that he could turn against Whewell, and the effect was, I have no doubt, to soften the adverse criticisms, and to produce an article on the whole favorable to the book, and one that even Comte himself regarded with some complacency. Mill got wind of the two volumes in the end of 1837, after he had completed the draft of his book on Induction. The "Autobiography" gives (pp. 210–214) the general effect produced upon him by the whole work, which he perused with avidity as the successive volumes appeared; but does not adequately express the influence in detail, nor the warmth of esteem and affection displayed in the five years of their correspondence from 1841 to 1846. In our many conversations during the summer of 1842, Mill occasionally mentioned Comte, but not in a way to give me any clear conception of what his merits consisted in. Among his associates at that time was William Smith, lately dead, and known as the author of "Thorndale" and various other works. He was a pupil of the Mills in philosophy, and occupied himself in contributing to magazines. In the winter of that year, he wrote a review of Comte in "Blackwood" (March, 1843), giving very well-selected extracts; and from these I derived my first impression of the peculiar force of the book. I remember particularly being struck with the observations on the metaphysical and critical stage, as a vein of remark quite original.

It was in the summer of that year (1843) that I read the work for myself. I was in London as before, and had the same opportunities of conversing with Mill. We discussed the work chapter by chapter, up to the last volume, which I had not begun when I left town. We were very much at one, both as to the merits and as to the defects of the work. The errors were mostly of a kind that could be remedied by ordinary men better informed on special points than Comte; while the systematic array was untouched. The improvement effected in the classification of the sciences was apparent at a glance; while the carrying out of the hierarchy, involving the dependence of each science upon the preceding, first as to doctrine, and next as to method, raised the scheme above the usual barrenness of science-classifications. Mill had already seized with alacrity, and embodied in the "Logic," Comte's great distinction between social statics and social dynamics; and I was even more strongly impressed than he respecting the value of

that distinction as an instrument of social analysis. Comte, according to his plan of pushing forward the ideas of each of the fundamental sciences into the succeeding, had taken up the distinction in abstract mechanics, and carried it first into biology, where it made his contrast between anatomy and physiology—structure and function. The next step was to sociology, and led to the distinction of order and progress. I confess that I never thought the three cases exactly parallel; still, however the distinction came, it was invaluable in sociology; and Comte's separation of the two interests—social order and social progress—was a grand simplification of the subject, and a mighty advance upon the historical and political philosophy of his predecessors and contemporaries. The social statics he discussed briefly, as compared with the magnitude of the topics, but indicated well enough what these topics were; the social dynamics enabled him to give free scope to his doctrine of the Three Stages, and carry this out in a grand survey of the historical development of mankind. Here, of course, he exposed a wide front to criticism; but, while numerous exceptions might be taken to his interpretations of history, it was truly wonderful to see how many facts seemed to fall in happily under his formulas. Mill, it will be seen from the "Logic" (book vi., chapter x.), accepted the Three Stages as an essential part of Comte's historical method, which method he also adopts and expounds as the completion of the logic of sociology. In our very first conversations, I remember how much he regretted Comte's misappreciation of Protestantism; and he strove in the early part of their correspondence to make him see this. He also endeavored to put him right on the specialty of England in the political evolution.

It is curious to observe that his altered estimate of Comte never extended to the views appropriated from him on the method of social science. The modifications in the later editions consisted mainly in leaving out the high-pitched compliments to Comte in the first; none of the quotations are interfered with. I give a few examples of these omissions. Referring to the latest edition, the eighth, on page 490, he writes: "The only thinker who, with a competent knowledge of scientific methods in general"; in the first edition—"The greatest living authority on scientific methods in general." On page 506, line five from bottom, before "To prove (in short)," the first edition has—"It is therefore well said of M. Comte." In page 512, line thirteen from top, the words "but deem them" are followed in the first edition by "with the single exception of M. Comte." In page 513, line nine from top, after "up to the present time," a long sentence of reference to Comte is left out. In page 530, line fourteen from top, after "attempting to characterize," there is omitted the clause—"but which hitherto are to my knowledge exemplified nowhere but in the writings of M. Comte."

The distinction of statics and dynamics was carried by Mill into

the plan of his "Political Economy." It also entered into his "Representative Government"; and, if he had written a complete work on sociology, he would have made it the basis of his arrangement as Comte did.

Mill's correspondence with Comte began in 1841. I heard from himself a good deal of the substance of it as it went on. Comte's part being now published, we can judge of the character of the whole, and infer much of Mill's part in the work. In 1842 and 1843 the letters on both sides were overflowing with mutual regard. It was Comte's nature to be very frank, and he was circumstantial and minute in his accounts of himself and his ways. Mill was unusually open; and revealed, what he seldom told to anybody, all the fluctuations in his bodily and mental condition. In one of the early letters, he coined the word "pedantocracy," which Comte caught up, and threw about him right and left, ever after. Already in 1842 troubles were brewing for him in Paris, partly in consequence of his peculiar tenets, and still more from his unsparing abuse of the notables of Paris, the foremost object of his hate being the all-powerful Arago. His personal situation, always detailed with the utmost fullness, makes a considerable fraction of the correspondence on his side. When in 1843 the "Polytechnic pedantocracy," that is to say, the Council of the Polytechnic School, for which he was examiner, first assumed a hostile attitude, and when his post was in danger, Mill came forward with an offer of pecuniary assistance, in case of the worst; the generosity of this offer will be appreciated when I come to state what his own circumstances were at that moment. Comte, however, declined the proposal; he would accept assistance from men of wealth among his followers; indeed, he broadly announced that it was their duty to minister to his wants; but he did not think that philosophers should have to devote their own small means to helping one another. Mill sent the "Logic" to him as soon as published; he is overjoyed at the compliments to himself, and warmly appreciates Mill's moral courage in owning his admiration. They discuss sociological questions at large, at first with considerable cordiality and unanimity; but the harmony is short-lived. In the summer of 1843 begins the debate on women, which occupied the remainder of that year; the letters being very long on both sides. By November, Comte declares the prolongation of the discussion needless; but protests strongly against Mill's calling women "slaves." Mill copied out the letters on both sides, and I remember reading them. Some years later, when I asked him to show them to a friend of mine, he consented, but said that, having reread them himself, he was dissatisfied with the concessions he had made to Comte, and would never show them to any one again. What I remember thinking at the time I read them was, that Mill needlessly prolonged the debate, hoping against hope to produce an impression upon Comte. The correspondence was not arrested by this divergence, nor was

Mill's sympathy for Comte's misfortunes in any way abated; but the chance of their ever pulling together on social questions was reduced to a very small amount. They still agreed as to the separation of the spiritual and the temporal power, but only as a vague generality. In July, 1844, came the crash at the Polytechnic; by a dexterous manœuvre, Comte was ousted without being formally dismissed; he lost six thousand francs a year, and was in dire distress. He appealed to Mill, but with the same reservation as before; Mill exerted himself with Grote and Molesworth, who with Raikes Currie agreed to make up the deficiency for the year. Another election came round, and he was not reinstated, and was again dependent on the assistance of his English friends. They made up a portion of his second year's deficiency, but declined to continue the grant. He is vexed and chagrined beyond measure, and administers to Mill a long lecture upon the relations of rich men to philosophers; but his complaint is most dignified in its tone. This puts Mill into a very trying position; he has to justify the conduct of Grote and Molesworth, who might with so little inconvenience to themselves have tided him over another year. The delicate part of the situation was that Grote, who began admiring Comte, as Mill did, although never to the same degree, was yet strongly adverse to his sociological theories, especially as regarded their tendency to introduce a new despotism over the individual. Indeed, his admiration of Comte scarcely extended at all to the sociological volumes. He saw in them frequent mistakes and perversions of historical facts, and did not put the same stress as Mill did upon the social analysis — the distinction of statics and dynamics, and historical method; in fact, he had considerable misgivings throughout as to all the grand theories of the French school in the philosophy of history. But the repression of liberty by a new machinery touched his acutest susceptibility; he often recurred in conversation to this part of Comte's system, and would not take any comfort from the suggestion I often made to him that there was little danger of any such system ever being in force. It was the explanation of this divergence that Mill had to convey to Comte; who, on the other hand, attempted in vain to reargue the point by calling to mind how much he and Mill were agreed upon, which, however, did not meet Grote's case. He returned to the theme in successive letters, and urged upon Mill that there was an exaggeration of secondary differences, and so on. What may be said in his favor is that Grote turned round upon him rather too soon. This was in 1846. The same year his Clotilde died. He still unfolded his griefs to Mill, and, as may be supposed, received a tender and sympathizing response. The correspondence here ends.*

* Although Mill was the first and principal medium of making Comte and his doctrines familiar to the public, he was soon followed by George Henry Lewes, who was beginning his literary career, as a writer in reviews, about the year 1841. I met Lewes frequently when I was first in London in 1842. He sat at the feet of Mill, read the

I must still come back to the year 1842. In the October number of the "Westminster Review" for that year was published his article on Bailey's "Theory of Vision," in which he upheld the Berkeleian doctrine against Bailey's attacks. I remember his saying that he went to the country, on one occasion, from Friday till Tuesday, and in the three days wrote this article. With all his respect for Bailey, he used a number of expressions very derogatory to his understanding; attributing to him such things as a "triumphing over a shadow," "misconceiving the argument he was replying to," etc. Bailey was much hurt at the time by these expressions; and Mill's reply on this point is very characteristic ("Dissertations," ii., 119): "To dispute the soundness of a man's doctrines and the conclusiveness of his arguments, may always be interpreted as an assumption of superiority over him; true courtesy, however, between thinkers, is not shown by refraining from this sort of assumption, but by tolerating it in one another; and we claim from Mr. Bailey this tolerance, as we, on our part, sincerely and cheerfully concede to him the like." This was his principle of composition throughout his polemical career, and he never departed from it. Of Bailey's reply on this occasion, he remarked: "The tone of it is peevish. But Bailey is, I know, of that temper—or rather I infer it from sundry indications."

ATLANTIS NOT A MYTH.

By EDWARD H. THOMPSON.

OUR sturdy worker in the copper mines of Lake Superior, finding both himself and his vein of copper growing poorer day by day, determines to seek some more paying claim in the as yet unexplored portion of the copper country. He gathers his kit of tools together and starts, and, after many a hard hour's travel over the wild and rugged country, finds a region with abundant signs of copper, and where seemingly no human foot has trod since creation's dawn.

He strikes a rich vein and goes steadily to work digging and blasting his way to the richer portions, when suddenly, right in the richest part, he finds his lead cut off by what looks to his experienced eye marvelously like a mining shaft. Amazedly he begins to clear out of the pit the fallen earth and the *débris* of ages, and the daylight thus let in reveals to his astonished gaze an immense mass of copper raised

"Logic" with avidity, and took up Comte with equal avidity. These two works, I believe, gave him his start in philosophy; for, although he had studied in Germany for some time, I am not aware that he was much impressed by German philosophy. In an article in the "British and Foreign Review," in 1843, on the modern philosophy of France, he led up to Comte, and gave some account of him.

some distance from the original bottom of the pit on a platform of logs, while at his feet lie a number of strange stone and copper implements—some thin and sharp like knives and hatchets, others huge and blunt like mauls and hammers—all being left in such a manner as though the workman had but just gone to dinner and might be expected back at any moment. Bewildered, he ascends to the surface again and looks about him. He sees mounds that from their positions are evidently formed from the refuse of the pit, but these mounds are covered with gigantic trees, evidently the growth of centuries; and, looking still closer, he sees that these trees are fed from the decayed ruins of trees still older—trees that have sprung up, flourished, grown old, and died since this pit was dug or these mounds were raised. The more he thinks of the vast ages that have elapsed since this pit was dug, that mass of copper quarried and raised, the more confused he becomes: his mind can not grasp this immensity of time.

"Who were these miners? When did they live, and where did they come from?" are the questions he asks himself, but gets no answer. However, one fact is patent to him—that, whoever they were, they will not now trouble his claim; and, consoled by this reflection, he goes to work again.

The traveler in wandering through the dense and almost impenetrable forests of Central and South America, suddenly finds himself upon a broad and well-paved road, but a road over which in places there have grown trees centuries old. Curiously following this road, he sees before him, as though brought thither by some Aladdin's lamp, a vast city, a city built of stone—buildings that look at a distance like our large New England factories—splendid palaces and aqueducts, all constructed with such massiveness and grandeur as to compel a cry of astonishment from the surprised traveler—an immense but deserted city, whose magnificent palaces and beautiful sculpturing are inhabited and viewed only by the iguana and centiped. The roads and paths to the aqueducts, once so much traveled as to have worn hollows in the hard stone, are now trodden only by the ignorant mestizo or simple Indian. Of this deserted home of a lost race, the traveler asks the same question as the miner, and the only answer he gets from the semi-civilized Indian is a laconic "*Quien sabe?*" And who does know?

The curious and scientific world, however, are not so easily answered, and various are the theories and conjectures as to these diggers of mines and builders of mounds and strange cities. One of the most plausible of these — one believed by many scientists to be the true theory—is this: Ages ago the Americas presented a very different appearance from what they now do. Then an immense peninsula extended itself from Mexico, Central America, and New Granada, so far into the Atlantic that Madeira, the Azores, and the West India Islands are now fragments of it. This peninsula was a fair and fertile country inhabited by rich and civilized nations, a people versed in the arts

of war and civilization—a country covered with large cities and magnificent palaces, their rulers according to tradition reigning not only on the Atlantic Continent, but over islands far and near, even into Europe and Asia. Suddenly, without warning, this whole fair land was ingulfed by the sea, in a mighty convulsion of nature.

Now, this catastrophe is not impossible or even improbable. Instances are not wanting of large tracts of land, several hundred miles in extent, disappearing in a like manner. The island of Ferdinandea suddenly appeared, and after a while as suddenly disappeared. In 1819, during an earthquake in India, an immense tract of land near the river Indus sank from view, and a lake now occupies its place.

The whole bed of the Atlantic, where Atlantis is said to have been situated, consists of extinct volcanoes. The terrible Lisbon earthquake of 1755, and the later American shock, created a commotion throughout the whole Atlantic area.

That Atlantis possessed great facilities for making a sudden exit can not be doubted. Its very situation gives good color to the narratives of ancient Grecian historians and Toltecian traditions, that "it disappeared by earthquakes and inundations."

Not only is it within the bounds of possibility that it might have occurred, but if traditions so clear and distinct as to be almost authentic history are to be believed, then it did occur. Listen to what one of the most cautious of ancient writers, Plato, says: "Among the great deeds of Athens, of which recollection is preserved in our books, there is one that should be placed above all others. Our book tells us that the Athenians destroyed an army that came across the Atlantic seas, and insolently invaded Europe and Asia, for this sea was then navigable; and beyond the straits where you place the Pillars of Hercules was an immense island, larger than Asia and Libya combined. From this island one could pass easily to the other islands, and from these to the continent beyond. The sea on this side of the straits resembled a harbor with a narrow entrance, but there is a veritable sea, and the land which surrounds it is a veritable continent. On this island of Atlantis there reigned three kings with great and marvelous power. They had under their domain the whole of Atlantis, several of the other islands, and part of the continent. At one time their power extended into Europe as far as Tyrrhenia, and uniting their whole force they sought to destroy our country at a blow, but their defeat stopped the invasion and gave entire freedom to the countries this side of the Pillars of Hercules. Afterward, in one day and one fatal night, there came mighty earthquakes and inundations, that ingulfed that warlike people. Atlantis disappeared, and then that sea became inaccessible, on account of the vast quantities of mud that the ingulfed island left in its place." It is possible that the *débris*, said to have been left by this catastrophe, might be identical with or the nuclei of the *sargazo* fields that, many centuries later,

Columbus found almost impenetrable. Again, Plato, in an extract from Proclus, speaks of an island in the Atlantic whose inhabitants preserved knowledge from their ancestors of a large island in the Atlantic, which had dominion over all other islands of this sea.

Plutarch, in his life of the philosopher Solon, Herodotus, and other ancient writers, speak of this island as a known fact, and it is impossible to believe otherwise than that Seneca thought of Atlantis when he writes in his tragedy of "Medea": "Late centuries will appear, when the ocean's veil will lift to open a vast country. New worlds will Thetsys unveil. Ultima Thule" (Iceland) "will not remain the earth's boundary." He evidently believed in the unknown island and continent, and knew it would not remain for ever unknown.

Diodorus Siculus says that "opposite to Africa lies an island which, on account of its magnitude, is worthy to be mentioned. It is several days distant from Africa. It has a fertile soil, many mountains, and not a few plains, unexcelled in their beauty. It is watered by many navigable rivers, and there are to be found estates in abundance adorned with fine buildings." Again he says, "Indeed, it appears on account of the abundance of its charms as though it were the abode of gods and not of men."

The situation, the description of the country, in fact every particular, agrees precisely with our idea of Atlantis; and what other land now in existence agrees in any way with this description—what islands of magnitude that contain navigable rivers, large fertile plains, and mountains?

Turning from our well-known ancient writers, we find in all the traditions and books of the ancient Central Americans and Mexicans a continual recurrence to the fact of an awful catastrophe, similar to that mentioned by Plato and others.

Now, what are we to believe? This, that either the traditions and narratives of these ancient writers and historians of both lands are but a tissue of fabrications, evolved from their own brains, with perhaps a small thread of fact, or else that they are truths, and truths proving that the Americas, instead of being the youngest habitation of man, are among the oldest, if not, as De Bourbourg affirms, the oldest.

Brasseur de Bourbourg, who Baldwin says has studied the monuments, writings, and traditions left by this civilization more carefully and thoroughly than any man living, is an advocate of this theory, and to him are we indebted for most of our translations of the traditions and histories of the ancient Americans.

To the imaginative and lovers of the marvelous, this theory is peculiarly fascinating, and the fact that there is plausible evidence of its truth adds to the effect. With their mind's eye they can see the dreadful events, as recorded by Plato, as in a panorama. They see the fair and fertile country, filled with people, prosperous and happy; the sound of busy life from man and beast fills the air. Comfort and prosperity

abound. The sun shines clear overhead, and the huge mountains look down upon the cities and villages at their feet, like a mother upon her babes: all is a picture of peacefulness. Suddenly, in a second, all is changed. The protecting angels become destroying fiends, vomiting fire and liquid hell upon the devoted cities at their feet, burning, scorching, strangling their wretched inhabitants. The earth rocks horribly, palaces, temples, all crashing down, crushing their human victims, flocked together like so many ants. Vast rents open at their very feet, licking with huge, flaming tongues the terrified people into their yawning mouths. And then the inundations. Mighty waves sweep over the land. The fierce enemies, Fire and Water, join hands to effect the destruction of a mighty nation.

How they hiss and surge, rattle and seethe! How the steam rises, mingled with the black smoke, looking like a mourning-veil, that it is, and, when that veil is lifted, all is still, the quiet of annihilation! Of all that populous land, naught remains save fuming, seething mud. It is not to be supposed that all perished in that calamity. Long before this they had spread over the portion of the Americas contiguous to the peninsula, building cities, palaces, roads, and aqueducts, like those of their native homes; and adventurous pioneers continually spreading north, east, and westward, their constant increase of numbers from their former homes enabling them to overcome the resistance offered to their progress by both natives and nature, till at last they reached and discovered the copper country of Lake Superior. That they appreciated this discovery is evinced by the innumerable evidences of their works and of their skill in discovering the richest and most promising veins. Wherever our miners of the present day go, they find their ancient fellow craftsmen have been before them, worked the richest veins and gathered the best copper; and it is supposed that they continued thus till the terrible blotting out of their native country cut short all this, and left this advancing civilization to wither and die like a vine severed from the parent stem.

Having no further accession to their numbers, and being continually decimated by savages and disease, they slowly retreated before the ever-advancing hordes. Gradually, and contesting every step, as is shown by their numerous defensive works along their path, they were forced back to their cities on this continent, that had been spared them from the universal destruction of their country, where the dense and almost impassable forests afforded them their last refuge from their enemies, and where, reduced by war, pestilence, and other causes, to a feeble band, their total extinction was only a matter of time. Such is probably the history of this lost civilization, and such would have been the history of our civilization had we in our infant growth been cut off from receiving the nourishment of the mother countries.

Within the last twenty-five years, all sciences relating to the past

and present of man have been enormously developed. Old, worn-out, useless theories have been discarded, new facts have taken their places, discoveries have followed discoveries, each discovery helping to form, link by link, the chain of human history.

We are beginning to perceive that we are but yet young in the knowledge of human history, that we have as yet picked up but a bright pebble of thought or glittering shell of theory, while before us lies the whole vast sea of human history unexplored. That we are beginning to acknowledge this is a good sign, for, when a man or mankind acknowledge their ignorance, they have at least a sure foundation to build upon.

Again, the spirit of bigotry, the spirit that told men to scorn and deride Galileo and Columbus, is fast passing away, and in its stead comes the spirit of rationality, a spirit that tells men to look upon a new idea or theory, even if it does run outside of the accustomed rut, with a reasoning if not favorable eye. And we have faith, as science grows to grander proportions and dispels some of the mist that now envelops it, that some day not far distant will bring forward an historic Edison that shall bring together the faint voice of the prehistoric past and the bright, clear voice of the present; that some future Champollion will discover, among the ruined cities of the Americas, an American Rosetta-stone that will complete the chain of human history. "The noblest study of mankind is man."

MICRO-ORGANISMS AND THEIR EFFECTS IN NATURE.

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WHAT is too small to be seen, people are generally apt to regard with contempt or indifference, as of no practical consequence. This is one of the grossest of popular errors. There is not only a profound scientific interest in the realm of microscopic life, which is every day becoming deeper as its organisms are viewed from the standpoint of evolution, but they have a significance in the economy of nature, a usefulness to man, and a value in the industrial arts, of which but few glimpses have as yet been popularly obtained. To the inquiry, Of what service are those swarms of infinitesimal objects which are revealed only through the microscope? do they subserve any other purpose than to amuse infatuated microscopists?—the reply is, that their operations in nature are on a grand and imposing scale, and that their influence on man and other organisms, as well as on the air, the water, and the solid earth, is nothing less than enormous.

Although we do not see these infinitesimal creatures at work, their proceedings are none the less real; and though their operations are infinitesimal, the aggregate results are vast and in the highest degree important. It may be shown—1. That, as *food*, they feed a greater number of beings than any other kind of organisms; 2. That, as *scavengers*, they eat more refuse than any other group of organisms; 3. That, despite their minuteness, their *fossil remains* are much greater in *bulk* and of far more consequence than those of large quadrupeds and serpent-like monsters, such as the *mastodon*, *megatherium*, *plesiosaurus*, *ichthyosaurus*, etc.; 4. That, as *builders*, they have produced immense structures, which far surpass in size all the colossal works of man. The evidence of these statements will be presently given; but meantime it may be remarked that such grand results redeem the study of microscopical objects from that pettiness which is often imputed to it.

But not alone because of their stupendous effects are these invisible creatures entitled to our attention. It is in the simplest and smallest creatures that we find the alphabet of the science of life. The rudimentary objects of biology are invisible; and the language of the science could never have been acquired except by first learning its A, B, C with the microscope. It is by the study of the lowest elementary forms of life that we become enabled to comprehend its higher and more complex forms, and we never could have done it otherwise. The anatomy and physiology of our own bodily structures have their roots in the invisible. The grand chain-work of relations that binds all things in order thus loses itself at one extreme in the infinitely great, and at the other in the infinitely small. Embryology, the playground of evolution, shows us microscopic embryos like adult micro-forms as necessary links in the unity of natural phenomena, so that the relationship of living things can only be comprehended by a study of the minutest objects. I do not, however, propose here to enlarge upon this aspect of the subject, but simply to offer a few illustrations of the importance of these micro-organisms.

Let us first consider the relations of microscopic animals to the crust of the earth, and notice what they have had to do with its formation and constitution. From their low grade of organization they are naturally supposed to have been the earliest creatures on our globe, and there is evidence in favor of this. In ancient geological ages, in whose rocks they are scarce, or hardly to be found at all as fossils, there lived numerous worms, mollusks, etc., which could not have subsisted without them as food. We may conclude, with some degree of certainty, that they were almost as plentiful then as now, probably more so; but we could not expect these delicate and minute objects to remain preserved until the present, to have withstood the metamorphoses of the very rocks in which they were imbedded. On this account they are exceedingly rare in the oldest formations, while the

shells of various kinds are extremely numerous in modern rocks and earth. Still, the earliest fossil known, the *Eozoön Canadense*, the organic nature of which was formerly questioned, but now seems certain, belongs to the Azoic rocks. This determination of life in what was formerly regarded as the Azoic or lifeless age, has necessitated the establishment of an age of Dawn-life, hence named Eozoic. Life in Azoic time was also inferred from its immense quantities of carbon and of graphite, the most ancient deposits of which might be of organic origin. But aside from the Eozoön fossils, we appear to have further positive evidence of life in rhizopod fossils of Stromatopore structure, as discovered in the so-called green-stones of the Huronian, as well as in the great bog-ore deposits, which were evidently formed, then as now, through the agency of swampy vegetation.

It now seems most likely that flints, called *silicic rocks*, because they contain so much of the glass-substance known as silica, were largely produced from silicic organic remains, and the correctness of this view is strongly sustained by the microscope discovering in most flinty masses the crystalline needles of sponges, incasements of diatoms, capsules of infusorians, or spheroid frames of rhizopods. The silica which percolates and hardens petrified wood and other fossils may have originated chiefly from organic structures. Also, we find in chalk the molds of the silicic parts of animals, but the silica is dissolved out and gone.

The greatest use of those animalcules which have the body of plasma incased by a cell-membrane, and are called *infusorians*, will be pointed out further on, yet their influence on the crust of our globe must be noticed here; for a few of these bear shells and hence are found in a petrified state. Their fragmentary shells almost compose the *flint* rocks at Delitzsch, near Leipsic, Saxony, while some of the living sorts occur as fossils in the coal and chalk formations. Many *green-sand rocks*, even as far down as the Silurian, consist mainly of similar silicic shells, or the nuclei or molds of their chambers. The *whetstones* so extensively manufactured from the lower green-sand stone in the Black-Down Hills of England, have probably derived their useful qualities from them. Also, the silicic *polishing-stone*, called tripoli, or Polirschiefer, in Germany, not only contains such shells, but is entirely composed of them. This substance is used chiefly as a powder for polishing metals and stones. Infusorial formations of similar character are found at Cassel, Planitz, and Bilin. The layer at Bilin, in Bohemia, is fourteen feet thick, and Ehrenberg has estimated that it contains 41,000,000,000 shells in every cubic inch, while all are united and imbedded by an amorphous silicic substance forming compact masses of rock. At Agea, in Bohemia, there is another deposit two miles long, with an average thickness of twenty-eight feet. Its upper layer is about ten feet thick, and consists wholly of such shells; while the lower eighteen feet is a dense

mixture of these with a fine granular substance. Other similar deposits appear in many parts of the world.

The many *silicic clays* owe their peculiar characters to the microscopic fossils they have contained. The *sands* and *mergel* of Sienna and Coroncina, in Italy, imbed great quantities. The lanceolets, the lowest of vertebrates, the mud-eating fishes, and the dirt-eaters among men, subsist chiefly from these tiny organisms, for the so-called "*edible earths*" and "*infusorial earths*" are made up largely of, and owe their nutritive qualities to, the remains of microscopic animals. These earths are eaten in times of need by the Lapps and Tungusians. They are likewise used in South America, in New Caledonia, Kurdistan, in China, and in some of our own Southern States. The "bread-stone" of China belongs to this kind of food. On the shores of a lake near Uranea, in Sweden, there is a large deposit of infusorial powder called *Bergmehl* (mountain-meal), which is mixed with flour and eaten. It consists almost entirely of microscopic shells.

The animalcules of plasma without a cover of cell-membrane are known as *rhizopods*, or root-footed animals. These have been of the *greatest benefit* in geological history. Those which have a central spore-case are called *radiolarians*, and generally bear beautiful spheroid, radiate, silicic frames, which have assisted largely in producing great flinty deposits in the depths of the sea, constructing extensive masses of rock. There is no doubt that they helped greatly in the formation of the silicic rocks of Virginia, the Nicobar Islands, Sicily, Barbadoes, etc. Indeed, this latter island consists almost entirely of their remains, and two hundred and thirty-two kinds have been described on it alone. Also the barren rocks, twenty feet thick, on which the city of Richmond, Virginia, stands, consist mainly oftheir discoid shells.

Other rhizopods, called *foraminifers*, produce porous, calcareous incasements for themselves and help form limestone rocks.

Surprising as it may sound, it is nevertheless true that substantially the rhizopods built the temples and mammoth pyramids of Egypt and the stone walls of Vienna and Paris, for the very rocks of these structures, as well as those which surround the Mediterranean Sea and extend thence to the Himalayan Mountains, are chiefly built up by their infinitely numerous perforated shells. There are extensive *limestone formations*, which have resulted mainly from their remains, and some of these bear their names, as the miliolithic, of the Paris basin ; that of the Vienna basin ; the alveolithic, of western France ; and the nummulithic, of the Mediterranean. Limestones composed chiefly, sometimes entirely, of their shells, appear in the Grob-Kalk of Gentilly and in very many other localities, also forming a broad belt along both sides of the Mediterranean Sea and eastward therefrom, sometimes hundreds of feet in thickness.

But what is still more astonishing is the fact that the whole geological formation known as the *cretaceous* or *chalk* has been produced

almost entirely by their porous shells—that the immense chalk cliffs and downs along the English Channel and elsewhere have resulted from masses of their shells, and that they thus bear the same relation to the Cretaceous or Chalk as do plants to the Carboniferous or Coal age. The very dust of those chalky regions was once alive! Of course, many other kinds of organisms helped to some extent in the formation of cretaceous deposits, but the great bulk was undoubtedly of rhizopod origin. Standing at Dieppe, France, beneath the immense chalk cliffs of the English Channel, one can hardly realize that these beds of solid chalk, hundreds of feet in thickness, are the produce of such diminutive beings. But when we reflect that the chalk is five hundred and thirty-five feet high at Beachy Head, and five hundred feet at Wendover Hill, that it has been bored into five hundred and ten feet at Diss, in Norfolk, and that its average thickness has been estimated by reliable geologists, such as De la Bêche and others, at about seven hundred feet, while it extends through all the northern part of France as far south as Aix-la-Chapelle, thence northward to Denmark and through the south part of England to the Isle of Wight; and that its outcroppings have been traced from the north of Ireland to the south of France and eastward to the borders of Asia Minor, while a belt of cretaceous deposits extends around the earth just north of the equator, and numerous other chalk regions occur, like that reaching from Terra del Fuego to New Granada, in South America, besides those in our own country—very extensive in the Western, less so in the Southern States—we begin to perceive in what overwhelming quantities these organisms have existed, and what a stupendous work they have performed. The microscopic animals of the Cretaceous may be individually insignificant, but *en masse* they are certainly far more important than such larger fossils as the *mosasaurus*, *pterodactylus*, *iguanodon*, *ichthyosaurus*, and species of large fossil turtles of the same age, or the elephant-like mastodons and ponderous, sloth-like megatheriums of more modern date. The microscopic shells, which chalk contains, are mostly in a fragmentary condition, yet plenty are entire enough to be readily identified, and the number of different kinds (species) involved was very great, for about three hundred species have been described. Twenty of these species are *still living* and more or less actively engaged, along with other living species, in the construction of *modern* chalk, or the chalk-mud of the Atlantic basin. Here in the bottom of the sea we have chalk in the actual process of formation to-day. It was long since said by Dr. Mantell that "chalk forms such an assemblage of sedimentary deposits as would probably be presented to observation if a mass of the bed of the Atlantic two thousand feet in thickness were elevated above the waters and became dry land; the only essential difference would be the generic and specific characters of the imbedded animal and vegetable remains," * and

* "Wonders of Geology," 1848, vol. vi., p. 305.

this view has lately been substantiated by the deep-sea investigations of English naturalists. Wyville Thomson says: "There can be no doubt whatever that we have forming at the bottom of the present ocean a vast sheet of rock which very closely resembles chalk; and there can be as little doubt that the old chalk, the Cretaceous formation, which in some parts of England has been subjected to enormous denudation, and which is overlaid by the beds of the Tertiary series, was produced in the same manner and under closely similar circumstances"; and he also thinks it is "probable that in the deeper parts of the Atlantic a deposit, differing possibly from time to time in composition, but always of the same general character, might have been accumulating continuously from the Cretaceous, or even earlier periods, to the present day."* What enormous swarms and successive generations of rhizopods have existed, to effect such amazing results! Were all the extinct chalk animals resurrected at once, they would envelop the earth as did the primitive waters before the land was apart from the sea; we should have an ocean of protoplasm filled with their shells. Figuier truly says: "With these microscopic animals Nature has worked wonders in geological times; nor have those wonders ceased in our days."

Their diminutive size, marvelous reproductive capacity, and tenacity of life, together with the readiness with which they adapt themselves to new and various conditions of existence, not only have insured them a wide *distribution* in space, but also have enabled them to survive the destructive causes which exterminated higher forms through long and successive ages of geological time. Among about one hundred and twenty-five kinds (genera) of shelled, root-footed animals, only about fifteen are not fossil. Of the one hundred and ten species of those with perforated shells now living in the Atlantic chalk-ooze, the number of species common to it and the various geological formations in England is estimated as fifty-three with the crag, twenty-eight with the London clay, nineteen with the chalk, seven with the Rhætic and Upper Trias, one with the Permian, and one with the Carboniferous. The survival of so many species in the group is a striking testimony against the theory that the species of each geological division of time ended in a totally demolishing and exterminating catastrophe. The links in their chain are small but numerous, continuously uniting the organic life of remote ages with that of to-day.

At present the immense numbers of their shells on some shores is remarkable; indeed, the sands of some localities are largely composed of them. D'Orbigny obtained 3,800,000 porous shells from a single ounce of sand on the shores of the Antilles. According to Soldani, one ounce of sand from Rimini, on the Adriatic, yields 6,000 shells. This scientist described and figured a great number of these in Italy, publishing an elaborate folio work with 228 copperplate illustrations,

* "Depths of the Sea," p. 470.

and then destroyed the whole edition a few days afterward, because he could find only six purchasers of the work, to the preparation of which he had devoted twenty years of his life! These organisms were as poorly appreciated then as now. Max Shultze reports that he has separated 1,500,000 specimens from one ounce of sifted sand from the coasts of Italy, near Mola di Gaeta. Also the deep-sea sands are in great part made up of their shells. In most of these the perforated forms abound, but in many localities the silicic symmetrical frames are most numerous. Until recently the great depths of the ocean were supposed to be dark, barren wastes; that the lack of oxygen, with the immense pressure of water from above, rendered these abysses impenetrable and uninhabitable. But the success of modern deep-sea soundings, particularly in the region of the Atlantic cable, has shown that the Atlantic ooze or chalk-mud, of which the ocean-bed is so largely composed, is literally alive with protoplasmic animalcules, whose innumerable shells and calcareous deposits give to this ooze its peculiar character, and are virtually constructing beds of chalk. These and other facts have led some of our best authorities to believe that the formation of chalk has been a continuous process from the Cretaceous time to the present.

In their geographical distribution most have an extremely wide range, and great numbers of species are cosmopolitan in their occurrence, yet there is a general uniformity of the conditions under which they exist. For example, *globigerina* appears often in such great depths of the ocean that the temperature of its habitat hardly varies with the seasons, or even for different zones, while the same species under different conditions of depth, temperature, etc., does show very strong varieties, which are sometimes so markedly distinct as to be accounted different species and genera, as has often been asserted by Carpenter, Williamson, and others. Professor Carpenter also states that Messrs. Parker and Jones became so familiar with the geographical variations of the species of perforated shells, that they could judge from the appearance of a specimen whence it came.

The *infusorians* belong chiefly to the fresh water, being plentiful in all lakes, ponds, swamps, rivers, and smaller streams, while only a few are marine; contrariwise, the rhizopods are mostly found in the seas, a small number inhabiting fresh waters. The rhizopods also serve an important function in the depths of the sea by setting free in the water large supplies of carbonic and phosphoric acids. Certain infusorian lash-swimmers (*noctiluca*, etc.) sometimes make the ocean look red or bloody by day and illumine it with phosphorescence at night. This is often observed in the Red Sea, in the Gulf of Guinea, off the north of France, on the Peruvian coasts, and in the Gulf of California, which on this account was called Mar Vermijo, or Vermilion Sea, by the early Spanish navigators.

With few exceptions, microscopic beings possess the power of

moving from place to place, although many enjoy this freedom for only a part of their lifetime, and then become adherent or attached to foreign bodies for the rest of their existence. But even with the most rapid, free swimming forms, so little distance can be accomplished in their almost momentary lives, that their voluntary progressions can have little or no effect on their geographical distribution. In this they are creatures of chance or circumstance. Multiplying in myriads, and being too small and weak to resist the elements, they are constantly swept about in currents of water or air, and in the moisture on the surfaces of moving animals, etc. Well-authenticated observations show that with the evaporation of ponds and other waters containing swarms of these little animals, many encyst themselves within delicate capsules formed of an exudation, which hardens the body-surface; they then dry up and become as particles of dust, which are wafted from place to place by the winds, and for weeks or months may lie in the mud, dust, or snow, on hay, moss, branches of trees, etc. Others decompose, but leave behind their germs, which are distributed in the same way. By these means they are scattered everywhere, and those which chance to fall into favorable situations survive and produce swarms of progeny, while others, falling on bad ground, perish. Thus they are ready to do their appointed work, whenever and wherever it is needed. It is commonly thought that pure drinking-water is filled with these microscopic creatures, and it is sometimes said that they constitute the life of the water, while in their absence it becomes dead, stagnant, and often slimy, green, and unfit for use. All this is the opposite of the facts. Pure water is not inhabited by organisms; on the contrary, stagnant water or impure water alone affords them subsistence. They hasten the destruction of dead animal and vegetable matters the water may contain, causing for the time being an infusion or fermentation, which results finally in the purification of the liquid in question.

The bodily corruption in diseases, whether contagious or not, is not caused alone by the swarms of infesting organisms associated therewith, but is simply their cause, a sustenance for them, itself making their existence and multiplication possible.

The unaccounted-for readiness of these animalcules to spring up wherever decaying organic matter existed, first suggested the name *infusoria*, and led to the early false opinions that they were generated by the decomposition and fermentation of organic bodies, and to the modern reformed theory of *spontaneous generation*.

Strangely seeming, yet true, stagnation, death, decay, are replete with life when viewed through lenses, so that it has become a scientific doctrine that all organic decomposition and fermentation is assisted and sustained by these tiny creatures. Hence we may regard them as the most important scavengers of earth, water, and air.

While their devouring work is as a "bottling up" of injurious and

infectious matters, thus purifying our world, the substances their little bodies may contain and their parasitic action when inoculated into the bodies of higher living organisms by contact, inhalation, eating, etc., render some kinds extremely dangerous as conveyers of the various contagious diseases, hence to be strenuously avoided by strict cleanliness and rigid hygienic measures of every kind. Such knowledge has done much toward inducing modern purity, and has led to our recently improved treatment of wounds and sores by the antiseptic method, whereby many benefits result and great numbers of lives are saved.

THE SCIENCE AND PHILOSOPHY OF RECREATION.*

By GEORGE J. ROMANES.

IN all places of the civilized world, and in all classes of the civilized community, the struggle for existence is now more keen than ever it has been during the history of our race. Everywhere men, and women, and children are living at a pressure positively frightful to contemplate. Amid the swarming bustle of our smoke-smothered towns, surrounded by their zone of poisoned trees, amid the whirling roar of machinery, the scorching blast of furnaces, and in the tallow-lighted blackness of our mines—everywhere, over all the length and breadth of this teeming land, men, and women, and children, in no metaphor, but in cruel truth, are struggling for life. Even our smiling landscapes support as the sons of their soil a new generation, to whom the freedom of gladness is a tradition of the past, and on whose brows is stamped, not only the print of honest work, but a new and sadding mark—the brand of sickening care. Or if we look to our universities and schools, to our professional men and men of business, we see this same fierce battle rage—ruined health and shattered hopes, tearful lives and early deaths being everywhere the bitter lot of millions who toil, and strive, and love, and bleed their young hearts' blood in sorrow. In such a world and at such a time, when more truly than ever it may be said that the whole creation groans in pain and travail, I do not know that for the purposes of health and happiness there is any subject which it is more desirable that persons of all classes should understand than the philosophical theory and the rational practice of recreation. For recreation is the great relief from the pressure of life—the breathing-space in the daily struggle for existence, without which no one of the combatants could long survive; and therefore it becomes of the first importance that the science and the philosophy of such relief should be generally known. No doubt it is true that people will

* Expanded from notes of a Lecture delivered before the National Health Society.

always be compelled to take recreation and to profit by its use, whether or not they are acquainted with its science and its philosophy; but there can be equally little doubt that here, as elsewhere, an intelligent understanding of abstract principles as well as of practical applications will insure more use and less abuse of the thing which is thus intelligently understood.

With a view, then, of obtaining some such intelligent understanding of recreation, let us begin by clearly understanding what recreation means. First of all, the mere word, like many of our other English words that signify abstractions, condenses much philosophy within itself. For, as "creation" means a forming, "re-creation" means a forming anew; and, as in etymological derivation, so in actual truth re-creation is nothing other than a re-novation of the vital energies; leisure time and appropriate employment serve to repair the organic machinery which has been impaired by the excess of work. The literal meaning of the word is therefore in itself instructive, as showing that what our forefathers saw in recreation was not so much play, pastime, or pleasantry, as the restoration of enfeebled powers of work. And I do not know that within the limits of one word they could have left us a legacy of thought more true in itself or more solemn in its admonition. Recreation is, *or ought to be*, not a pastime entered upon for the sake of the pleasure which it affords, but an act of duty undertaken for the sake of the subsequent power which it generates, and the subsequent profit which it insures. Therefore, expanding the philosophy which is thus condensed in our English word, we may define recreation as that which with the least expenditure of time renders the exhausted energies most fitted to resume their work. Such is my definition of recreation; yet I know that many things are called by this name which can not possibly fall within this definition, and I doubt whether nine persons out of ten ever dreamed either of attaching such a meaning to the word, or of applying such a principle to the thing. Nevertheless, I also know that in whatever degree so-called recreation fails to be covered by this definition, in that degree does it fail, properly speaking, to be recreation at all. It may be amusement, fun, or even profitable employment; but it is not that particular thing which it is the object of this paper to consider. Therefore the definition which I have laid down may be taken as a practical test of recreation as genuine or spurious. If recreation is of a kind that renders a man less fitted for work than would some other kind of occupation, or if it consumes more time than would some other kind of occupation which would secure an equal amount of recuperation, then, in whatever degree this is so, in that degree must the quality of such recreation be pronounced impure.

So much, then, for the meaning of recreation. The next point that I shall consider is the physiology of recreation. It may have struck some readers as a curious question, why some actions or pur-

suits should present what I may call a recreative character, and others not. For it is evident that this character is by no means determined by the relief from *labor* which these actions or pursuits secure. A week on the moors involves more genuine hard work than does a week in the mines, and a game of chess may require as much effort of thought as a problem in high mathematics. Moreover, the same action or pursuit may vary in its recreative quality with different individuals. Rowing, which is the favorite recreation of the undergraduate, is serious work to the bargeman; and we never find a gardener to resemble his master in showing a partiality to digging for digging's sake. If it is suggested that it is the need of bodily exercise which renders muscular activity beneficial to the one class and not to the other, I answer, no doubt it is so partly, but not wholly; for why is it that a man of science should find recreation in reading history, while an historian finds recreation in the pursuit of science? or why is it that a London tradesman should find a beneficial holiday in the country, while a country tradesman finds a no less beneficial holiday in London? The truth seems to me to be that the only principle which will serve to explain the recreative quality in all cases is what I may call the physiological necessity for frequent change of organic activity, and the consequent physiological value of variety in the kinds and seasons of such activity. In order to render this principle perfectly clear, it will be necessary for me very briefly to explain the physiology of nutrition.

When food is taken into the body it undergoes a variety of processes which are collectively called digestion and assimilation. Into the details of these processes I need not enter, it being enough for my present purpose to say that the total result of these processes is to strain off the nutritious constituents of the food, and pour them into the current of the blood. The blood circulates through nearly all the tissues of the body, being contained in a closed system of tubes. This system of tubes springs from the heart in the form of large, hollow trunks which ramify into smaller and smaller tube-branches. These are all called arteries. The smaller arteries again ramify into a countless meshwork of so-called capillaries. Capillaries are also closed tubes, but differ from arteries in being immensely more numerous, more slender, and more tenuous in their walls. These capillaries pervade the body in such an intimate meshwork that a needle's point can not be run into any part of the body where they occur without destroying the integrity of some of them, and so causing an outflow of blood.

As these capillaries ramify from the arteries, so do they again coalesce into larger tubes, and these into larger, and so on, until all this system of return tubing ends again in the heart in the form of large, hollow trunks. The tubes composing this system of return tubing are called the veins. Thus the whole blood-vascular system may be likened to two trees which are throughout joined together by their leaves, and

also by cavities at the bottoms of their trunks—the heart. The branches of both trees being everywhere hollow, the contained fluid runs up the stem, and through smaller and smaller branches of the arterial tree, into the delicate vessels of the leaves, which may be taken to represent the capillaries. Passing through these into the twigs of the venous tree, the blood returns through larger and larger branches of this tree till it arrives at the trunk, and completes its circuit by again entering the trunk of the arterial tree through the cavities of the heart. Now the blood, in perpetually making this complete circuit of the body, performs three important functions: it serves to carry oxygen from the lungs to all the other parts of the body; it serves to supply all parts of the body with the nutritive material with which it is charged; and it serves to drain off from all the tissues of the body the effete products which they excrete, and to present these effete products to the organs whose function it is again to abstract them from the blood and expel them from the body. The two latter functions of the blood —those of nourishing and draining—I must consider more in detail. They are both performed in the capillaries, so that the object of the arteries and veins may be considered as merely that of conveying the blood to and from the capillaries. Moreover, both functions are performed by transfusion through the delicate walls of the capillaries—the nutritive material in the blood being thus transfused into the surrounding tissues, and the waste product of these tissues being transfused into the blood. Thus, in the various vascular tissues there is always a double process going on: first, that of receiving nourishment from the blood, whereby they are being constantly built up into an efficient state for the performance of their various functions; and, secondly, that of discharging into the blood the effete materials which the performance of these functions entails. Now, when any tissue or organ is in a state of activity in the performance of its function, the activity which it manifests entails a process of disintegration, which is the reverse of the process of nutrition; that is to say, when a tissue or organ is doing its work, it is expending energy which it has previously derived in virtue of the process of nutrition. Work is therefore, so to speak, the using up of nutrition; so that if the income of energy due to nutrition is equal to the expenditure of energy due to work, the tissue or organ will remain stationary as regards its capacity for further work, while, if the work done is in excess of the nutrition supplied, the tissue or organ will soon be unable to continue its work; it will become, as we say, exhausted, cease to work, and remain passive until it is again slowly and gradually refreshed or built up by the process of nutrition. Therefore all the tissues and organs of the body require periods of rest to alternate with periods of activity; and what is true of each part of the body is likewise true of the body as a whole—sleep being nothing other than a time of general rest during which the process of nutrition is allowed to gain upon that of exhaustion. Thus we

may have local exhaustion—as when the muscles of our arm are no longer able to hold out a heavy weight—or we may have general exhaustion, as in sleep; and we may have local restorations due to nutrition—as when our exhausted arm, after some interval of rest, is again able to sustain the weight—or we may have a general restoration due to nutrition, as in the effects of sleep.

I have now said enough about the physiology of nutrition to render quite clear what I mean by recreation depending on the physiological necessity for a frequent change of organic activity. For although in the case of some organs—such as most of the secreting organs—activity is pretty constant, owing to the constant expenditure of energy being just about balanced by the constant income, in the case of nerves and muscles this is not so; during the times when these organs are in activity their expenditure of energy is so vastly greater than their income during the same times, that they can only do their work by drawing upon the stores of energy which have been laid up by them during the comparatively long periods of their previous rest. Now, recreation applies only to nerve and muscle; and what it amounts to is simply this—a change of organic activity, having for its object the affording of time for the nutrition of exhausted portions of the body. A part of the body having become exhausted by work done, and yet the whole of the body not being exhausted so far as to require sleep, recreation is the affording of local sleep to the exhausted part by transferring the scene of activity from it to some other part. Be it observed that a certain amount of activity is necessary for the life and health of all the organs of the body; so it would not do for the community of organs as a whole that, when any one set become exhausted by their own activity, all the others should share in their time of rest, as in general sleep. But, by transferring the state of activity from organs already exhausted by work to organs which are ready nourished to perform work, recreation may be termed, as I have said, local sleep.

Thus we see that, in a physiological no less than in a psychological sense, the term re-creation is a singularly happy one; for we see that, as a matter of fact, the whole physiology of recreation consists merely of a re-building up, re-forming, or re-creation of tissues which have become partly broken down by the exhausting effects of work. So that in this physiological sense recreation is partial sleep, while sleep is universal recreation. And now we see why it is that the one essential principle of all recreation must be that of variety of organic activity; for variety of organic activity merely means the substitution of one set of organic activities for another, and consequently the successive affording of rest to bodily structures as they are successively exhausted. The undergraduate finds recreation in rowing because it gives his brain time to recover its exhausted energies, while the historian and the man of science find recreation in each other's labors

because these labors require somewhat different faculties of mind for their pursuance.

Before concluding these general remarks on the physiology of recreation, I must say a few words with more special reference to the physiology of exercise. We do not require science to teach us that the most lucrative form of recreation for those whose labor is not of a bodily kind is muscular exercise. Why this should be so is sufficiently obvious. The movement of blood in the veins is due to two causes.

The act of drawing breath into the lungs, by dilating the closed cavity of the chest, serves also to draw venous blood into the heart. This cause of the onward movement of blood in the veins is what is called aspiration, and it occurs also in some of the larger veins of the limbs, which are so situated with reference to their supplying branches that movement of the limbs determines suction of the blood from the supplying branches to the veins. The second great cause of the venous flow is as follows: The larger veins are nearly all provided with valves which open to allow the blood to pass on toward the heart, but close against the blood if it endeavors to return back toward the capillaries. Now, the larger veins are imbedded in muscles, so that the effect of muscular contractions is to compress numberless veins now in one part and now in another part of their length; and, as each vein is thus compressed, its contained fluid is, of course, driven forward from valve to valve. Hence, as all the veins of the body end in the heart, the total effect of general muscular activity is greatly to increase the flow of venous blood into the heart. The heart is thus stimulated to greater activity in order to avoid being gorged with the unusual inflow of blood. So great is the increase of the heart's activity that is required to meet this sudden demand on its powers of propulsion, that every one can feel in his own person how greatly muscular exercise increases the number of the heart's contractions. Now, the result of this increase of the heart's activity is, of course, to pump a correspondingly greater amount of blood into the arteries, and so to quicken the circulation all over the body. This, in turn, gives rise to a greater amount of tissue-change—oxygenation, nutrition, and drainage—which, together with the increased discharge of carbonic acid by the muscles during their time of increased activity, has the effect of unduly charging the blood with carbonic acid and other effete materials. This increased amount of carbonic acid in the blood stimulates the respiratory center in the spinal cord to increase the frequency of the respiratory movements, so that under the influence of violent and sustained exercise we become, as it is expressively said, "out of breath." The distress to which this condition may give rise is, however, chiefly due to the heart being unable to deliver blood into the arteries as quickly as it receives blood from the veins; the result being a more or less undue pressure of venous blood upon a heart already struggling to its utmost to pump on all the blood it can. Training, which is

chiefly systematic exercise, by promoting a healthy concordant action between the heart and arteries, diminishes the resistance which the latter offer to an unusual flow of blood from the former, and therefore men in training, or men accustomed to bodily exercise, do not easily become distressed by sustained muscular exertion.

Now it is evident, without comment, how immense must be the benefit of muscular exercise. Not only does it allow time for the brain to rest when exhausted by mental work, but, by increasing the circulation all over the body, it promotes the threefold function of oxygenation, nutrition, and drainage. It thus refreshes the whole organism in all its parts ; it increases by use the strength and endurance of the muscles ; it maintains the heart and the lungs—or rather the whole of the circulatory and respiratory mechanisms—at the highest point of their natural efficiency ; and, in general, next only to air and food, muscular exercise is of all things most essential to the vitality of the organism.

So much, then, for the physiology of recreation ; and, having said this much on the abstract principles of our subject, I shall devote the rest of my paper to a consideration of this subject in its more practical aspects.

The fundamental principle of all recreation consisting, as I have said, in the rest from local exhaustion which is secured by a change of organic activity, it is clear that practical advice with regard to recreation must differ widely according to the class, and even the individual, to which it is given. Thus it would be clearly absurd to recommend a literary man, already jaded with mental work, to adopt as his means of recreation some sedentary form of amusement ; while it would be no less absurd to recommend a workingman, already fatigued with bodily toil, to regale himself with athletics. And, in lower degrees, the kind and amount of recreation which it would be wise to recommend must differ with different individuals in the same class of society, according to their age, sex, temperament, pursuits, and previous habits of life. But, although all matters of detail thus require to be adjusted to individual cases, there is one practical consideration which applies equally to all cases, and which must never be lost sight of if recreation of any kind is to produce its full measure of result. This consideration is the all-important part which is played in recreation by the emotions. It is, I am sure, impossible to over-estimate the value of the emotions in this connection—a prolonged flow of happy feelings doing more to brace up the system for work than any other influence operating for a similar length of time. The physiological reasons why this should be so are not apparent ; for, although we know that the emotions have a very powerful influence in stimulating the nerves which act on the various secreting organs of the body, I do not think that this fact alone is sufficient to explain the high value of pleasurable emotions in refreshing the nervous system. There

must be some further reason—probably to be sought for within the limits of the nervous system itself—why a flow of happy feelings serves to re-create the nervous energies. But, be the reasons what they may, we must never neglect to remember the fact that the influence of all others most detrimental to recreation is the absence of agreeable emotions or the presence of painful ones. There is, for instance, comparatively little use in taking so-called constitutional exercise at stated times, if the mind during these times is emotionally colorless, or, still worse, aching with sorrow and care. If recreation is to be of good quality, it must before all things be of a kind to stimulate pleasurable feelings, and while it lasts it ought to engross the whole of our consciousness. Half-hearted action is quite as little remunerative here as elsewhere; and, if we desire to work well, no less in play than in work must we fulfill the saying, "What thy hand findeth to do, do it with thy might."

Having stated this practical principle as of paramount importance in all recreation, I shall devote the rest of my space to giving a variety of suggestions concerning the recreation of all classes of society; and, for the sake of securing method to my discussion, I shall primarily consider the community in its most natural classes of men, women, and children.

There is not much to be said on the recreation of men belonging to the upper classes. That most objectionable of creatures, the gentleman at large without occupation, has a free choice before him of every amusement that the world has to give; but one thing he is hopelessly denied—the keen enjoyment of recreation. Living from year to year in a round of varied pastimes, he becomes slowly incapacitated for forming habits of work, while at the same time he is slowly sapping all the enjoyment from play. For, although variety of amusement may please for a time, it is notorious that it can not do so indefinitely. The intellectual changes which are involved in changes of amusement are not sufficiently pronounced to re-create even the faculties on which the sense of amusement depends; the mind, therefore, becomes surfeited with amusement of all kinds, just as it may become surfeited with a tune too constantly played—even though the tune be played in frequently changing keys. For such men, if past middle life, I have no advice to give. They have placed themselves beyond the possibility of finding recreation, and their only use in the world is to show the doom of idleness. They, more even than paupers, are the parasites of the social organism; and we can scarcely regret that their lumpish life, being one of stagnation self-induced, should be one of miserable failure, to the wretchedness of which we can extend no hope.

Turning next to gentlemen of active pursuits, I may most fitly begin with those who are beginning life at the universities. At our larger universities both the provisions for recreation and the manner

in which they are used are in a high degree satisfactory, and ought to serve as a model to universities all over the world. It may be true that at the Continental universities rowing would not inspire a tenth part of the enthusiasm which it creates at Oxford and Cambridge; and I know from experience that it is hopeless to persuade German students, as a class, to adopt what they consider childish toys—the bats and balls of cricket. All I can say is, so much the worse for the Continental universities. In everything that appertains to work—and more especially to original work—I am profoundly convinced that the sooner we copy something from the German universities the better; but, in most things that appertain to play, the English universities constitute the best models. Rowing, cricket, football, athletics, and, in a lower degree, gymnastics, bicycling, swimming, and riding, constitute, besides walking, the favorite modes of exercise; and it is impossible to suggest better. I have only to object that, regarded as recreation, there is, both at Oxford and Cambridge, far too much tendency to a specialization of these forms of exercise. Competition dictates practice, and practice entails too exclusive a devotion to the one kind of exercise which is practiced; so that, as a consequence, there is too sharp a division between the boating-men, the cricketers, and the athletes for securing the full benefit of exercise which all would derive if they were more usually to participate in one another's pursuits. But this evil is to some extent unavoidable, as it arises immediately from the spirit of emulation, without which the mere exercise would lose its zest, and so the fullness of its recreative value. Still, now that so many of the colleges are provided with their own cricket-grounds, and the boats are practically open to all, there is no reason why even the most ambitious aspirants to the "'varsity blue" should not enjoy more variety of exercise than is usually the case.

In the army and navy there is abundant time for recreation, which is too frequently wasted in mere lounging. When once the army or navy examinations are passed, there is comparatively little mental work required in the performance of duty, and therefore the comparatively large amount of leisure time which officers enjoy ought to be much more generally devoted than it is to reading, or even to original work. Officers constitute a class presenting no small proportion of intelligent members; so that the comparative rareness with which they present either high culture or proved powers of original work must, I think, be set down to a general bad habit or fashion of substituting idle amusement for profitable recreation.

To professional men, men of business, and indeed all who are engaged in pursuits requiring more or less severe mental work, coupled with more or less confinement, exercise is, of course, the *conditio sine qua non* of the recreation to be recommended. This fact is so obvious that I need not dwell upon it further than to make one remark. This is to warn all such persons that their feelings are no safe guide as to

the amount of muscular exercise that is requisite for maintaining full and *sustained* health. By habitual neglect of sufficient exercise the system may and does accommodate itself to such neglect ; so that not only may the desire for exercise cease to be a fair measure of its need, but positive exhaustion may attend a much less amount of exercise than is necessary to long continuance of sound health. However strong and well, therefore, a man may feel notwithstanding his neglect of exercise, he ought to remember that he is playing a most dangerous game, and that sooner or later his sin will find him out—either in the form of dyspepsia, liver, kidney, or other disease, which so surely creep upon the offender against Nature's laws of health. According to Dr. Parkes, the amount of exercise that a healthy man ought to take without fatigue is at the least that which is required for raising 150 foot-tons per diem. This, in mere walking, would, in the case of a man of ordinary weight, be represented by a walk of between eight and nine miles along level ground, or one mile up a tolerably steep hill ; but it is desirable that the requisite amount of exercise should be obtained without throwing all the work upon one set of muscles. For this reason walking ought to be varied with rowing, riding, active games, and, where practicable, hunting or shooting, which, to those who are fond of sport, constitute the most perfect form of recreative exercise.

Turning next to all the large class of men below the grade of clerks, their possible means of recreation are alike in this—that they must be more or less of a corporate kind. These men depend for their recreation on public institutions, and therefore it is of the first importance to the national health, happiness, morals, and intelligence that no thought, pains, or money should be spared in providing such institutions, adequate in number and competent in character to meet so important and so immense a need. Within the limits of so general an essay it is impossible to do anything like justice to this subject ; but I may say a few words on the kinds of institutions that I should most like to recommend.

Every town the size of which is so considerable that green grass and fresh air are not within easy reach of all its inhabitants, ought at any expense to be provided with public parks. In many of our large towns it is now virtually impracticable to provide such parks in central situations ; but even suburban parks are infinitely better than no parks at all. Public recreation-grounds having been provided, every inducement ought to be added to attract the people to use them. Gymnasia, boating, cricket and golf implements, lawn-tennis, and tennis-courts, ought all to be supplied at the public expense, so that workingmen and boys might be able to spend their holidays and half-holidays in healthy outdoor amusement without requiring to incur the expense of club subscriptions. Outdoor clubs, however, ought not the less to be encouraged for the sake of the additional inducement which *esprit de*

corps and competition give to outdoor recreation—the club subscriptions being limited to the providing of prizes. Bands ought also to be provided at the public expense to play in the parks during the spring and summer months on the afternoons of holidays and Sundays. The importance of this latter provision can not be too highly rated; for experience shows that wherever it has been tried its success has been astonishing. For instance, Lord Thurlow, quoting from Sir Benjamin Hall, stated to the House of Lords, on the 5th of May, that the Sunday visitors to Kensington Gardens had, by the band playing there, been increased from 7,000 to 80,000 in one day, and in the Regent's and Victoria Parks 190,000 had been attracted by the bands in one afternoon. When we consider what an amount of health, happiness, and refining influence these numbers represent as produced by a single cause, we blush for the narrow fanaticism which, in the name of religion, does all it can to deny to the working-classes the elevating influence of music on the only day that the toil of life admits of their obtaining it. I hold it to be impossible too strongly to deprecate the downright immorality of driving the working-classes by thousands into the pot-houses by depriving them of the innocent and refining enjoyment of music in the open air. Surely the common sense of the public, as a whole, is not so degraded by bigotry that, in the face of the figures I have quoted, there can any longer be a question in the public mind on the positive sin of allowing a puritanical spirit in the few to domineer over the health, the happiness, and the morals of the many.

Somewhat similar remarks apply to the question of opening museums and art-galleries on Sundays, though on this question the sabbatarians include among their ranks a greater proportional number of the community. In the debate of the 5th of May, to which I have already alluded, both Church and State, in so far as they are represented in the persons of the Primate and the Premier, spoke strongly against any reform in this direction; and, perhaps owing to this weight of united authority, the proposed reform was negatived by a majority of eight. Yet, when we examine the arguments which these high authorities were able to produce, we find them to be conspicuously of the feeblest kind. The leading argument both of the Prime Minister and of the Archbishop was that there is not sufficient evidence "of a very predominant sentiment" in favor of the reform on the part of workingmen themselves. Now, to this it may be answered, in the first place, that a poll on the question has not been taken, and that, therefore, it is a mere begging of the question to say that workingmen as a class "in all probability" do not desire the change. But, even if we grant that the working-classes as a whole are as apathetic upon the subject as they are represented to be, I do not see that this is any valid reason against reform. Possibly enough, the members of the House of Lords have a higher appreciation of the value of science-museums

and art-galleries, as well as the privileges and advantages of entering them, than have the members of workingmen's clubs; and I doubt not that, if the upper and the lower classes were for a few months to change places, petitions to Parliament of the kind which Lord Thurlow presented would be more numerous and more generally signed. But what does this argue? Surely not that we, who best know the culturing value of these institutions, ought to use the comparative ignorance of those who do not as an argument against extending to them the opportunity of ascertaining that value. On the contrary, in whatever degree indifference can be proved of the working-classes in this matter, it would seem to me a strong argument in favor of instilling into them a more lively perception of the educational advantages of such institutions; and this can only be done by throwing open these institutions on the (virtually) one day in the week when the classes in question are able to visit them. Of course, it may be said that the alleged indifference arises, not from ignorance of the value of such institutions, but from a preponderant sense of sabbatarianism on the part of the working-classes. But, supposing the alleged apathy to exist, and supposing it to arise from the latter cause alone—which I deem highly improbable—I still think it would constitute no valid argument against the proposed reform. We are all, I take it, agreed upon the recreative as well as what Lord Beaconsfield called the civilizing influence of the institutions in question; so that, upon the suppositions which I have made, the only issue to be considered is as to whether these benefits would be more than counterbalanced by the evils of offending the sense of sabbatarianism which is assumed so largely to predominate among the working-classes. And this introduces us to the second and only other argument which was adduced by Lord Beaconsfield. He said: "In all questions into which the religious sentiment enters, it is highly desirable that no change should be effected that is not called for by the expression of a very predominant sentiment on the part of the people." If this means that legislation ought not to interfere aggressively with the religious sentiments of the many, it is, no doubt, a proper utterance; but, if it means that the socially harmless and even beneficial recreation of the many is to be prohibited by the particular religious sentiments of the few—and this is what it does mean if the words are taken to mean what they say—then I think the utterance is most improper. The idea which underlies this utterance seems to be that the religious sentiment is of so much value to the state that it ought to be tenderly fostered in all its ramifications, even to the extent of preventing reforms conceded to be beneficial, lest they should prune the twigs of the structure thus tenderly fostered. Now, I do not wish to enter on the question as to how far the religious sentiment is of value to the state; for I think it is quite obvious in the present case that, let us place this value as high as we choose, the contemplated reform can not be other than complete-

ly beneficial. The workingmen who prefer spending their Sundays at home would not be injured by their brothers visiting museums and art-galleries; while, in so far as the religious sentiment is concerned, it ought to be a matter of gratification to all who entertain it that those workingmen who do not prefer spending their Sundays at home would, by the opening of such institutions, have an inducement supplied to turn their backs upon the beer-shops, and to bring their families to see the things of interest in nature, or the things of beauty in art. It is not that the opening of the institutions in question would act as a counter-inducement to that which is held out by the churches. Workingmen who are in the habit of going to church will, in any case, continue going to church, even though some of them may also spend their Sunday afternoons in the museums and galleries. And, so far as recreation is concerned, I am inclined to think it is not desirable that there should be any antagonism offered to the inducement which is held out by the churches. For I am inclined to think that the class of emotions which public worship arouses in a religious mind are of a high recreative value; and so, as a mere matter of sanitary interest, I should be sorry to see the churches interfered with by other institutions of a less recreative kind. But, in the present instance, the antagonism should not be museums and galleries *versus* chapels and churches, but museums and galleries *versus* public-houses and all places of loitering idleness; and any "religious sentiment" that seeks to oppose the introduction of such an antagonism can only be pronounced immoral.

Two other arguments against the reform were adduced in the debate, neither of which possesses the smallest validity. The Archbishop of Canterbury argued: "What were their lordships called upon to do to-night? It was before the eyes of the people of this kingdom, to pronounce a deliberate opinion that the policy with regard to the observance of the Sunday hitherto pursued in this country had been a mistake. . . . If any change were made, there was great danger of the day of rest being lost," as it would be the thin edge of the wedge to the introduction of other changes of a more advanced kind. Now, this is an argument which may always be adduced against any proposed reform, however obvious the need. We must not make the change because by so doing we should condemn the policy of the past and lead the way to further changes in the future. But, if a change is seen in itself to be desirable, such hypertrophied conservatism as this ought not to be allowed to obstruct progress. Moreover, in the present instance I am persuaded that the fears for the future are groundless. There is no necessary, or even remote, connection between art-galleries and music-halls; and, so long as "the religious sentiments" in this country remain what they are, neither religion nor reason will be able to trace a similarity or a precedent that does not exist.

The other argument to which I have alluded is, that the opening of museums and galleries on Sundays would entail a certain amount of

Sunday work on the part of porters, etc. To this argument it is sufficient to reply, in the first place, that, if desirable, voluntary labor of so light a kind would be forthcoming; and, next, in the words of the Earl of Derby, who "did not deny the extreme importance of maintaining the day of national rest; but they must recollect that, wherever recreation was allowed, some labor must be thrown on those who provided it. They permitted excursion-trains, etc., . . . and on the whole there was a great preponderance of advantage over disadvantage." As in most museums and galleries the porters and other servants employed on Sundays would probably not amount to one half per cent. of the visitors who would profit by their labor, I think that the argument may in this, more than in any other case of Sunday work, be set aside as absurd.

I have been tempted to dwell thus at considerable length on the question of Sunday recreation, because it is one that is now prominently before the public, and therefore I hope that a few words in season may help to hasten a reform which sooner or later is inevitable. As regards the recreation of workingmen, I have only further to say that institutions on the model of workingmen's clubs deserve to be encouraged in every possible way. Wealthy and benevolent persons could not do better with their means than to found such clubs where most required, and to endow them with a small annuity which would serve as a nucleus to club subscriptions, a greater number of subscribers being insured by the smaller amount of the fees. The Volunteer movement also deserves every encouragement, as supplying exercise and recreation to all classes at a very moderate cost.

Turning next to the recreation of women, I shall begin, as in the case of men, with the upper classes. And here, for the sake of emphasis, I shall confine my remarks to the one topic of muscular exercise. For ladies, more than any other section of the community, have fallen into the habit of neglecting exercise, and I am sure that I can not draw too dreadful a picture of the consequences which here arise from the too general custom. These consequences are all the more to be feared because many of them are of so insidious a kind that the root of the evil may never be suspected. It is not my intention to frighten any of the fair sex by unfolding a tale of horrors; so I will only say, in general terms, that I am quite sure among ladies there is no one source of disease and early death more prevalent than is this habitual violation of the best known among the laws of health. Consider for a moment what the life of a lady in town usually is. She rises probably at nine or ten o'clock, without much appetite for breakfast. Till luncheon she remains indoors, reading a novel or magazine, writing letters, or attending to her household duties. After luncheon she takes a little "carriage-exercise"—observe the unconscious irony of the term—pays a few afternoon calls, and returns home to afternoon tea. Until it is time to be dressed for dinner, there is another period

of total quiescence, and the tedious operations of the dressing-room which follow are certainly the reverse of recreation. Dinner in pleasant company no doubt affords recreation of a mental kind were such recreation required, which in this case it certainly is not. After dinner, during the season, she probably receives an evening party, goes to the opera, or indulges in some other kind of amusement which keeps her in hot rooms with vitiated air till the small hours of the morning. At last she retires to rest, complaining that her delicacy of constitution makes her a martyr to headaches, languid circulation, lassitude, and feelings of sickness. Now contrast such a wholly unnatural state of things with the daily life of a country girl to whom exercise is felt to be a *sine qua non* of existence, and do not wonder at the contrast between her state of blooming health and the feeble stamina of the lady whose position requires her to adopt the habits of town life. Ladies will no doubt tell me that these remarks are trite, and that they all knew before the desirability of taking exercise. I can only reply, if "ye knew these things happy are ye if you do them." And why not do them? Why not make the duty of taking daily exercise as important an article in your social creed as the duty of returning calls? If you say there is no time, the answer is preposterous. Senior wranglers could never have been senior wranglers had they not found time for their pull upon the Cam; and by not making time for exercise you are merely shortening the time of your life. Every day you can easily find time for a ride; or, if you are not able to ride, you may take every day a two hours' walk with some companion or object to make it a pleasurable walk. Such companions and objects are not difficult to obtain in the town; and in the country there are several kinds of outdoor amusements—such as rowing, riding, skating, lawn-tennis, etc.—which are happily recognized by the stern laws of etiquette as suitable for ladies, and which in performance are singularly graceful as well as highly conducive to good spirits. Dancing is also in itself an admirable form of exercise, though its beneficial effects are usually much more than counteracted by the late hours and excessive exhaustion of the ballroom. This excessive exhaustion of the muscular, but more especially of the nervous energies, may, in this as in all other similar cases, be properly denoted by the term which is the correlative of recreation—viz., dissipation. For although it has become customary to restrict the application of this term only to extreme cases, and to apply it to less extreme cases merely as a joke, both in etymology and in physiology the term dissipation is alike appropriate to all degrees of wasteful expenditure of the vital energies.

In recommending bodily exercise thus strongly, I speak of course to young and to middle-aged ladies; but I am sure that even here there are very few who could walk their five or six miles a day without fatigue. This merely shows to what a state of enervation their habitual neglect of exercise has reduced them. Such enfeebled per-

sons ought to begin at once to give their constitutions some chance of recovery; they ought regularly to take as much exercise as they can endure without distressing fatigue; and in a few months they would be surprised to find how greatly the length of their walks may be increased, and with what immense benefit they are attended.

Women in the lower classes of society may to a large extent share in the recreation of their male relatives; and I feel confident that the more those kinds of recreation are encouraged which invite participation by both sexes, the better. Great additional enjoyment is infused into a holiday if it can be spent in company with those most near and dear; the heart is then most open to the best influences of affection, and family ties are closest drawn in hours of happiness together. Such institutions as the Crystal and Alexandra Palaces, where a variety of amusements are provided at a cheap cost in country air and amid æsthetic surroundings, constitute the best type of institutions for the healthy and improving recreation of both sexes and all ages. Of parks and public pleasure-gardens I have already spoken, and the desirability of preserving commons and heaths in the near neighborhood of large towns is generally recognized. I will only add that no time ought to be lost in promoting the suggestion recently made to the First Commissioner of Public Works by the National Sunday League—viz., that in all such places of public resort harmless refreshments ought to be plentifully provided. As a type of more strictly town recreation, that which is afforded by the Polytechnic Institution deserves honorable mention, and the sustained popularity of the Moore and Burgess Minstrels' entertainment goes far to indicate that a much more healthy tone might be given to the entertainments which are generally provided by music-halls. Now that Cremorne Gardens, the Argyll Rooms, and similar places of public resort are being closed, there is certain to be a greater pressure of vice thrown upon the music-halls, and the increased demand for low, quasi-immoral entertainments which will thus be set up is only too certain to be supplied. It is greatly to be deplored that, excepting the "gods" galleries in theatres, there are now scarcely any places where respectable women of the lower classes can witness a public entertainment that is not more or less of a degrading kind. Philanthropists would do well to start in London several People's Theatres, where amusing dramas, part-singing, and other forms of innocent entertainment, would be sufficiently attractive to render the theatres self-supporting. I have no doubt that, if this were done, there would be a very marked distinction between the character of the audiences attending such theatres and that of the audiences which now attend the music-halls.

Before quitting the class of workingwomen, I must put in a good word for penny readings, mothers' meetings, window-gardening, and last, though not least, I should like to recommend some general and definite system for the loaning of books at a nominal cost.

We come now to the large and important class—children. It seems a mere commonplace to say that children ought to be allowed to run about and romp and play as much as ever they like or can. Yet this commonplace is far from having a common place in the usages of modern society. Among the upper classes children are much too frequently restrained from taking their full amount of natural play, either by preposterous ideas of genteel decorum, or by the respect due to expensive clothing; while among the lower classes the playground is too often restricted by the limits of the gutter, and even in the parks we too often witness the melancholy spectacle of children still a long way from their teens acting the part of nurse to still younger members of the family. To remedy these evils in the case of the upper classes there is nothing to suggest, except that fathers and mothers should cease to regard their children's clothes as of more importance than their children's health, and learn to estimate at its due value the responsibility of fostering the most precious of their possessions—these living, feeling, loving little ones whose capacities of life-long happiness are being molded by their parents' wisdom, or destroyed by their parents' folly. In the case of the lower classes, the *crèche*, or public nursery, where abundance of romping play is permitted, deserves the most strenuous encouragement. Children of all classes will play as they ought to play if only Nature is allowed to have her course without let or hindrance from artificial restraints.

But, as the only object in rearing children is not that of making them healthy animals, some amount of artificial restraint is necessary when the time for systematic mental training arrives. Nevertheless, as bodily health is the most essential condition even to mental training, the most fundamental principle which ought to guide the latter is that of supplying it with the minimum of cost to the former. Yet in school-life this fundamental principle is almost universally disregarded. So long as the general health of a school is maintained at a level compatible with work, and not below the level that declares itself by conspicuous "break-downs," so long nobody cares to reflect whether the system of school discipline is in all particulars the best for maintaining the general health at the highest possible level. I will not wait to consider the disgraceful food which, even in many of our better-class schools, is deemed sufficiently good for growing children to thrive upon; nor will I wait to inveigh against the system of competition which, when encouraged beyond moderate limits, acts as a baleful stimulus to the very pupils who least require to be stimulated. But, confining my remarks to the one particular of punishment, I should like to put it as a question of common sense, whether it would be possible to devise any mode of punishing school children at once more fatuous, more pernicious, or more opposed to every principle of science and morality, than are the modes which are now most generally in vogue. Consider for a moment the practice of giving "impositions."

It is not supposed that copying out a stated number of lines is an economical way of gaining information, so that even the plea of imparting instruction can not be advanced as a benefit to compensate the evil of the method. And this evil is a very serious one. The object of all our methods in education ought to be, as much as possible, to economize effort ; the mental energies ought, as it were, to be nursed, so that by their exercise they should lay up the largest possible store of information. But the mental energy which is expended in writing out an imposition is wholly, or almost wholly, profitless ; and the amount of energy so expended is considerable—especially in the case of long impositions. For the whole punishment of writing out an imposition consists in the *tediousness* of the process ; and tediousness, by the painful class of emotions which it arouses, is the most wearisome or exhausting of the influences that consume the nervous energies. It may therefore be said that in whatever degree the writing of an imposition is a punishment, in that degree are the nervous energies dissipated in a wholly useless manner. Therefore, to say nothing of the actual time that is wasted in the writing of impositions, or of the slovenly style of handwriting which this mode of punishment induces, my great objection to the mode of punishment is that, by consuming the nervous energies in a wholly profitless manner, it stands in direct antagonism with all the principles that I am endeavoring to inculcate. And still more foolishly wrong does this method of punishment become when it is united, as it generally is, with another and still more objectionable method—I mean the custom of imprisoning children during playtime with the express purpose of denying them healthful recreation. To shut up a child already weary with work in an empty schoolroom under a depressing sense of disgrace, is something worse than cruel ; to the child it is a wrongful injury that does not admit of being justified by any argument ; and, in running counter to all the principles both of physiology and of education, it is a sin against society. In most cases the time during which a child is thus confined is the only time in the twenty-four hours that there is an opportunity afforded for any recreation at all ; so that, when the weary time of solitude is over and school again meets, the unfortunate victim resumes work with energies doubly exhausted. Even if a child had the stamina of a man, it would be impossible that mental work resumed under such circumstances could be profitable—the faculty of memory being quickly affected by mental fatigue. But, as a matter of fact, owing to the great rapidity of physiological changes in a growing organism, a child has much more need of frequent exercise than has an adult ; so that, whether we look at the matter from a sanitary or from an educational point of view, I think it is impossible too strongly to condemn the practice of confining school children during playtime.

Of course I shall be asked what modes of punishment I would suggest as substitutes for the two which I have thus so strongly con-

demned. This question, however, I am not careful to answer. Even if it is true that there is a difficulty in providing other and efficient modes of punishment, I should not feel the difficulty to justify the maintenance of modes that are so clearly injurious. But, merely for the sake of giving an answer, I may say that, in the case of girls, experience derived from many of the higher-class schools shows that discipline may be maintained, either without any punishment at all, or else by such kinds as are more nominal than real. The difficulty in the case of boys is no doubt greater, but not, I think, insurmountable. Many kinds of punishment may here be devised which go upon the principle, not of denying muscular exercise, but of enforcing it. Extra drills or other compulsory exercise during play-hours are modes of punishment greatly to be preferred to those involving sedentary confinement, although I do not pretend to insinuate that compulsory exercise in the way of punishment has the same recreative value as voluntary exercise in the way of play. For my own part, I have no hesitation in recommending corporal punishment as on all grounds greatly preferable to the protracted, tedious, heart-sickening, and health-breaking systems which, in the name of humanity, are coming more and more into general use. But, however great the difficulty of devising or substituting other modes of punishment may be, I feel sure there can be no reasonable doubt that the modes which are at present so largely in fashion ought to be universally abolished.

The above remarks of course apply almost exclusively to boys' schools; and, looking to boys' schools as a whole, but little more remains to be said of them in connection with recreation. The John Bull spirit of this country is in favor of allowing schoolboys to play the hardy and vigorous games which require all the muscles to be brought into active service. The case, however, is widely different in girls' schools; so, before concluding, I should like to add a few words with special reference to them.

School-life is the time when, most of all, healthful recreation is needed. It is then that the organism, being in a state of active growth, most requires the purifying and strengthening influences of muscular exercise to be in frequent operation; and the development which the organism, during the years of its growth, receives, is carried through its life as an unalterable possession. Yet in the majority of girls' schools how miserable is the provision that is made for securing this development! Even in our higher-class schools the whole mechanism of their discipline seems to be devised with the view of stemming the healthful flow of natural joyousness by the barriers of tedious monotony. On all sides a schoolgirl is shut up in a very prison-house of decorum; every healthful amusement is denied her as "unladylike"; she is imperatively taught to curb her youthful spirits in so far as these may sometimes be able to struggle above the weight of a mistaken discipline; she is nurtured during her growth on the

unhealthy soil of *ennui* in a depressing atmosphere of dullness; and, as too frequent a consequence, she leaves school with a sickly and enervated constitution, capable perhaps of high vivacity for a short time, but speedily collapsing under the strain of a few hours of bodily or mental activity. Now all this is the precise reverse of what school-life ought to be. The only aim of most of the higher girls' schools seems to be that of turning out pupils with a superficial knowledge of a variety of subjects, with such accomplishments as they may be able, by hard practice, to acquire, and with a well-drilled sense of the part that a young lady is to play in the complicated tragedy of etiquette. Now it is no doubt sufficiently desirable that girls, and especially young ladies, should be well educated; but, in my opinion, it is of far greater importance that schoolgirls should leave school with the maximum of bodily vigor that a wise and judicious nurture can impart, than that they should do so with minds educated to any level that you please to name within the limits of natural possibility. I should therefore like to see all girls' schools professedly regarded as places of recreation no less than as places of education—as places of bodily, no less than as places of mental culture. And, if this is considered too strong a statement of the case, it must at least be allowed that far more permanently beneficial work would be done by girls, both at school and after they leave it, if more permanently beneficial play were allowed. At present in most schools, with all indoor romping sternly forbidden as unladylike, all outdoor games regarded as impossible recreations for girls of their age and social position, the unfortunate prisoners are restricted in their exercise to a properly prison-like routine—a daily walk in twos and twos, all bound by the stiff chains of conventionality, with nothing to relieve the dull monotony of the well-known way, and one's constant companion being determined, not by any entertaining suitability of temperament, but by an accidental suitability of height. Could there be devised a more ludicrous caricature of all that we mean by recreation?

Do we want to know the remedy? The remedy is as simple as the abuse is patent. Let every school whose situation permits be provided with a good playground, and let every form of outdoor amusement be encouraged to the utmost. Schools situated in towns, and therefore unable to provide private playgrounds, might club together and rent a joint playground—care, of course, being taken that the social standing of all the schools which so club together should be about equal. Some such arrangement would soon be arrived at by town schools if parents generally would bestow more thought on the importance of their children's health, and turn a deaf ear to all the qualifications of a school, however good, which does not provide for the proper recreation of its pupils.

Of course I shall be met by the objection that, by encouraging active outdoor games among schoolgirls, we should rub off the bloom,

so to speak, of refinement, and that, as a result, we should tend to impair the delicate growth of that which we all recognize as of paramount value in education—good breeding. I can only say I am fully persuaded, by the results I have seen, that such would not be the case. The feelings and the manners of a lady are imparted by inheritance and by the society in which she lives, and no amount of drilling by schoolmistresses will produce more than an artificial imitation of the natural reality. Therefore, once let a girls' school be a little society of little ladies, and we need never fear that active play, natural to their age and essential to their health, will make them less ladylike than does the stiff restraint of the present system. Rather would active play, during the years of bodily growth, by developing the coördinated use of all the muscles, tend to impart through after-life that grace of easy movement which we all admire, but the secret of which is truly revealed only to the children of nature.

So much, then, for bodily recreation in girls' schools. As regards their mental recreation, I should begin by recommending less mental work. In most of the higher-class girls' schools, as in boys' schools, a great deal more work is required than it is either judicious or desirable to require. The root of this evil is that a girl's education is usually made to terminate at the age of seventeen or eighteen, and, as a consequence, she is expected to gain during these early years of life a sufficient amount of book-learning to serve for the rest of her days. In many cases it is, no doubt, unavoidable that a girl's education should end when she leaves school; but I think that, in all cases, education ought to be less arduous than it is in many of our girls' schools. Even if education is to end with school-life, it is better that it should end with a little knowledge thoroughly acquired, than with a confused and half-forgotten medley of many subjects. Not that I advocate specialty and depth of knowledge for girls. On the contrary, I think that the aim here ought rather to be that of generality and width—languages, elementary mathematics, geography, history, art, science, and English literature being all taught, but taught superficially, or without much detail, and in as entertaining a manner as possible. The point, however, which I desire chiefly to insist upon is this, that schoolgirls ought not to be made or encouraged to work beyond their strength. In most girls' schools competition runs very high; and I am quite sure that in very many cases the aim of the schoolmistress ought to be to check its undue severity, rather than to stimulate that severity by competitive examinations. I have myself known many cases of girls sitting up late, rising early, and working all day to win their coveted prizes—a state of things which is a sufficiently crying evil even in boys' schools, but which is a still worse evil in girls—worse because the physique of a girl is usually less robust than that of a boy, and because the schoolgirl is doomed to a smaller amount of outdoor exercise.

Now, if less time were consumed in girls' schools by mental work, more time would be allowed for mental as well as for bodily recreation. And, if the time thus gained were judiciously expended, I believe that, even as a matter of mental culture, more would be gained than lost. Suppose, for instance, that some time in every day were set apart for mental occupation of a voluntary kind—a good library of general though selected literature being provided for the use of the pupils, and the cultivation of art being allowed to rank as "mental occupation." In this way the more intellectual of the pupils would be able to receive that culture which only general reading can impart, the more artistic would be able to improve themselves in their art by additional practice, and even the unstudiously disposed would find in a standard novel a kind of reading less distasteful than Euclid.

And here, while treating of mental recreation among girls, I may add that school-life is the time when provision ought to be made for mental recreation in after-life. Be it observed that mental recreation is impossible unless there is a natural and more or less cultured taste for some branch or branches of mental work. Indeed, the capacity for such recreation is clearly proportional to the degree of such culture—an idealess mind being incapacitated for obtaining any *variety* of ideas. Hence the great importance of width of cultured interest, and the consequent duty of the heads of schools to ascertain the mental predilections of their pupils individually, and, in each case where such a predilection is apparent, to bestow special attention on its culture. If this were more generally done, I am convinced that the gain to their pupils in after-life would be enormous. We are living in a world teeming with interest on every side, but to make this interest our own possession we require a trained intelligence. It ought, therefore, to be one of the first aims of education to supply special training to special aptitudes, whereby the mind may be brought *en rapport* with the things in which it is by nature fitted to take most interest, and so in them to find a never-ending source of mental recreation. If this method were more universally adopted in girls' schools, ladies as a rule would be supplied with more internal resources of mental activity and cease to be so dependent for the stimulation of such activity on the mere excitement which is supplied by the external resources of society. But as it is, whether in the concert-room, the picture-gallery, the library, or the country walk, it is of most ladies literally and lamentably true, that having eyes they see not, and having ears they hear not, neither understand. Most ladies have a natural taste for some one or other of the many lines of intellectual activity, and if this taste were developed in early life it would grow with the knowledge on which it feeds, till in mature life it would become an unfailing source of pleasurable recreation. Yet in most cases such a taste in early life is not so much as discovered. For instance, how seldom it is that we meet, even among musical ladies, with any knowledge of harmony!

—and this simply because they have never ascertained whether the study of harmony might not be to them a study of absorbing interest. Or, again, how very rare a thing it is to meet a lady who has even a superficial acquaintance with any one of the sciences; and how vast is the paradise of intellectual enjoyment from which multitudes of intelligent ladies are thus excluded! And similarly with all the other lines of intellectual pursuit for which a certain small amount of rudimentary initiation is required in order to ascertain whether they are suited to individual taste. So that, as I have said, one of the most important aims of a girl's, and also of a boy's, education ought to be to ascertain and specially to cultivate the branch of knowledge in which most interest is taken. Let us not suppose that by following this advice there is any danger of imparting to young ladies that singularly objectionable and not very easily definable character which is most tersely and intelligently conveyed by the word "blue." No one can have a more intense dislike than I have of the cerulean tint; but, wherever I have seen it, I have always been persuaded that it is the previous character which has tinted the learning—not the learning which has tinted the character. Only let a lady be a lady, and nothing but envious ignorance can ever venture to breathe the objectionable word, while cultured refinement in the opposite sex will always discover in the culture of a lady that only which adds to her refinement.

I have now said all that I feel it desirable to say on the principles and the practice of recreation; and I will conclude by adding a few words on what I may call the ethics of recreation.

Health may be taken as implying capacity for work, as well as to a large, though to a less absolute degree, the capacity for happiness; and, as duty means our obligation to promote the general happiness, it follows that in no connection is the voice of duty more urgent than it is in the advancement of all that is conducive to health. By maintaining our own health at the highest point of its natural efficiency, we are doing all that in us lies to secure for ourselves the prime condition for work—that is, the prime condition for benefiting the community to whatever extent our powers may be capable. And, similarly, by promoting the health of others, we are, in proportion to our success, securing to the community a certain amount of additional capacity for work on the part of its constituent members, as well as increasing the individual capacity for happiness on the part of all the members whom our efforts may reach. Therefore, I take it that, if we regard this subject from an ethical point of view, it is clear that we have no duty to perform of a more grave and important kind than this—thoughtfully to study the conditions of health, earnestly to teach these conditions to others, and strenuously to make their observance a law to ourselves. Now, of these conditions one of the most important is suitable recreation. For this is the condition which extends to all classes of the community, and the observance of which is, as we have

seen, an imperative necessity to every individual who desires to possess a sound working mind in a sound working body. Hence I do not hesitate to say that one of our most weighty duties in life is to ascertain the kinds and degrees of recreation which are most suitable to ourselves or to others, and then with all our hearts to utilize the one, while with all our powers we encourage the other. Be it remembered that by recreation I mean only that which with the least expenditure of time renders the exhausted energies most fitted to resume their work; and be it also remembered that recreation is necessary not only for maintaining our powers of work so far as these are dependent on our vitality, but also for maintaining our happiness so far as this is dependent on our health. Remembering these things, I entertain no fear of contradiction when I conclude that, whether we look to the community as a whole, or restrict our view to our own individual selves, we have no duty to discharge of a more high and serious kind than this—rationally to understand and properly to apply the principles of all that in the full but only legitimate sense of the word we call recreation. Again, therefore, I say, if we know these things, happy are we if we do them. And if we desire to do them—if as rational and moral creatures we desire to obey the most solemn injunction that ever fell from human lips, "Work while it is day"—we must remember that the daylight of our life may be clouded by our folly or shortened by our sin; that the work which we may hope to do we shall be enabled to do only by hearkening to that Wisdom who holdeth in her right hand length of days, in her left hand riches and honor; and that at last, when all to us is dark with the darkness of an unknown night, such Wisdom will not have cried to us in vain, if she has taught us how to sow most plenteously a harvest of good things that our children's children are to reap.—*Nineteenth Century.*

MYTHOLOGIC PHILOSOPHY.*

By Major J. W. POWELL.

I.—The Genesis of Philosophy.

THE wonders of the course of nature have ever challenged attention. In savagery, in barbarism, and in civilization alike, the mind of man has sought the explanation of things. The movements of the heavenly bodies, the change of seasons, the succession of night and day, the powers of the air, majestic mountains, ever-flowing rivers, perennial springs, the flight of birds, the gliding of serpents,

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the growth of trees, the blooming of flowers, the forms of storm-carved rocks, the mysteries of life and death, the institutions of society—many are the things to be explained. The yearning to know is universal. *How* and *why* are everlasting interrogatories profoundly instinct in humanity. In the evolution of the human mind, the instinct of cosmic interrogation follows hard upon the instinct of self-preservation.

In all the operations of nature, man's weal and woe are involved. A cold wave sweeps from the north—rivers and lakes are frozen, forests are buried under snows, and the fierce winds almost congeal the life-fluids of man himself, and indeed man's sources of supply are buried under the rocks of water. At another time the heavens are as brass, and the clouds come and go with mockery of unfulfilled promises of rain, the fierce midsummer sun pours its beams upon the sands, and scorching blasts heated in the furnace of the desert sear the vegetation, and the fruits, which in more congenial seasons are subsistence and luxury, shrivel before the eyes of famishing men. A river rages and destroys the adjacent valley with its flood. A mountain bursts forth with its rivers of fire, the land is buried and the people are swept away. Lightning shivers a tree and rends a skull. The silent, unseen powers of nature, too, are at work bringing pain or joy, health or sickness, life or death, to mankind. In like manner man's welfare is involved in all the institutions of society. *How* and *why* are the questions asked about all these things—questions springing from the deepest instinct of self-preservation.

In all stages of savage, barbaric, and civilized inquiry every question has found an answer, every *how* has had its *thus*, every *why* its *because*. The sum of the answers to the questions raised by any people constitute its philosophy; hence all peoples have had philosophies consisting of their accepted explanation of things. Such a philosophy must necessarily result from the primary instincts developed in man in the early progress of his differentiation from the beast. This I postulate; if demonstration is necessary, demonstration is at hand. Not only has every people a philosophy, but every stage of culture is characterized by its stage of philosophy. Philosophy has been unfolded with the evolution of the human understanding. The history of philosophy is the history of human opinions from the earlier to the later days—from the lower to the higher culture.

In the production of a philosophy phenomena must be discerned, discriminated, classified. Discernment, discrimination, and classification are the processes by which a philosophy is developed. In studying the philosophy of a people at any stage of culture, to understand what such a people entertain as the sum of their knowledge it is necessary that we should understand what phenomena they saw, heard, felt, discerned; what discriminations they made, and what resemblances they seized upon as a basis for the classification on which

their explanations rested. A philosophy will be higher in the scale, nearer the truth, as the discernment is wider, the discrimination nicer, and the classification better.

The sense of the savage is dull compared with the sense of the civilized man. There is a myth current in civilization to the effect that the barbarian has highly developed perceptive faculties. It has no more foundation than the myth of the wisdom of the owl. A savage sees but few sights, hears but few sounds, tastes but few flavors, smells but few odors; his whole sensuous life is narrow and blunt, and his facts that are made up of the combination of sensuous impressions are few. In comparison the civilized man has his vision extended away toward the infinitesimal and away toward the infinite; his perception of sound is multiplied to the comprehension of rapturous symphonies; his perception of taste is increased to the enjoyment of delicious viands; his perception of smell is developed to the appreciation of most exquisite perfumes; and his facts that are made up of the combination of sensuous impressions are multiplied beyond enumeration. The stages of discernment from the lowest savage to the highest civilized man constitute a series the end of which is far from the beginning.

If the discernment of the savage is little, his discrimination is less. All his sensuous perceptions are confused; but the confusion is that universal habit of savagery—the confusion of the objective with the subjective, so that the savage sees, hears, tastes, smells, feels the imaginings of his own mind. Subjectively determined sensuous processes are diseases in civilization, but normal functional methods in savagery.

The savage philosopher classifies by obvious resemblances—analogic characters. The civilized philosopher classifies by essential affinities—homologic characteristics—and the progress of philosophy is marked by changes from analogic categories to homologic categories.

II.—Two Grand Stages of Philosophy.

There are two grand stages of philosophy—the mythologic and the scientific. In the first, all phenomena are explained by analogies derived from subjective human experiences; in the latter, phenomena are explained as orderly successions of events.

In sublime egotism man first interprets the cosmos as an extension of himself; he classifies the phenomena of the outer world by their analogies with subjective phenomena; his measure of distance is his own pace, his measure of time his own sleep, for he says, "It is a thousand paces to the great rock," or, "It is a hundred sleeps to the great feast." Noises are voices, powers are hands, movements are made afoot. By subjective examination discovering in himself will and design, and by inductive reason discovering will and design in his fellow men and in animals, he extends the induction to all the cosmos,

and there discovers in all things will and design. All phenomena are supposed to be the acts of some one, and that some one having will and purpose. In mythologic philosophy the phenomena of the outer physical world are supposed to be the acts of living, willing, designing personages. The simple are compared with and explained by the complex. In scientific philosophy, phenomena are supposed to be children of antecedent phenomena, and so far as science goes with its explanation they are thus interpreted. Man with the subjective phenomena gathered about him is studied from an objective point of view, and the phenomena of subjective life are relegated to the categories established in the classification of the phenomena of the outer world; thus the complex is studied by resolving it into its simple constituents.

Some examples of the philosophic methods belonging to widely separated grades of culture may serve to make my statements clearer.

Wind.—The Ute philosopher discerns that men and animals breathe. He recognizes vaguely the phenomena of the wind, and discovers its resemblance to breath, and explains the winds by relegating them to the class of breathings. He declares that there is a monster beast in the north that breathes the winter winds, and another in the south, and another in the east, and another in the west. The facts relating to winds are but partially discerned; the philosopher has not yet discovered that there is an earth-surrounding atmosphere. He fails also in making the proper discriminations. His relegation of the winds to the class of breathings is analogic, but not homologic. The basis of his philosophy is personality, and hence he has four wind-gods.

The philosopher of the ancient Northland discovered that he could cool his brow with a fan, or kindle a flame, or sweep away the dust with the wafted air. The winds also cooled his brow, the winds also swept away the dust and kindled the fire into a great conflagration, and when the wind blew he said, "Somebody is fanning the waters of the fiord," or "Somebody is fanning the evergreen forests," and he relegated the winds to the class of fannings, and he said, "The god Hraesvelger, clothed with eagle-plumes, is spreading his wings for flight, and the winds rise from under them."

The early Greek philosopher discovered that air may be imprisoned in vessels or move in the ventilation of caves, and he recognized wind as something more than breath, something more than fanning, something that can be gathered up and scattered abroad, and so when the winds blew he said, "The sacks have been untied," or "The caves have been opened."

The philosopher of civilization has discovered that breath, the fan-wafted breeze, the air confined in vessels, the air moving in ventilation—that these are all parts of the great body of air which surrounds the earth, all in motion, swung by the revolving earth, heated at the tropics, cooled at the poles, and thus turned into counter-cur-

rents and again deflected by a thousand geographic features, so that the winds sweep down valleys, eddy among mountain-crags, or waft the spray from the crested billows of the sea, all in obedience to cosmic laws. The facts discerned are many, the discriminations made are nice, and the classifications based on true homologies, and we have the science of meteorology, which exhibits an orderly succession of events even in the fickle winds.

Sun and Moon.—The Ute philosopher declares the sun to be a living personage, and explains his passage across the heavens along an appointed way by giving an account of a fierce personal conflict between Ta-vi, the sun-god, and Ta-wats, one of the supreme gods of his mythology.

In that long ago, the time to which all mythology refers, the sun roamed the earth at will. When he came too near with his fierce heat the people were scorched, and when he hid away in his cave for a long time, too idle to come forth, the night was long and the earth cold. Once upon a time Ta-wats, the hare-god, was sitting with his family by the camp-fire in the solemn woods, anxiously waiting for the return of Ta-vi, the wayward sun-god. Wearied with long watching, the hare-god fell asleep, and the sun-god came so near that he scorched the naked shoulder of Ta-wats. Foreseeing the vengeance which would be thus provoked, he fled back to his cave beneath the earth. Ta-wats awoke in great anger, and speedily determined to go and fight the sun-god. After a long journey of many adventures the hare-god came to the brink of the earth, and there watched long and patiently, till at last the sun-god coming out he shot an arrow at his face, but the fierce heat consumed the arrow ere it had finished its intended course; then another arrow was sped, but that also was consumed; and another, and still another, till only one remained in his quiver, but this was the magical arrow that had never failed its mark. Ta-wats, holding it in his hand, lifted the barb to his eye and baptized it in a divine tear; then the arrow was sped and struck the sun-god full in the face, and the sun was shivered into a thousand fragments, which fell to the earth, causing a general conflagration. Then Ta-wats, the hare-god, fled before the destruction he had wrought, and as he fled the burning earth consumed his feet, consumed his legs, consumed his body, consumed his hands and his arms—all were consumed but the head alone, which bowled across valleys and over mountains, fleeing destruction from the burning earth until at last, swollen with heat, the eyes of the god burst and the tears gushed forth in a flood which spread over the earth and extinguished the fire. The sun-god was now conquered, and he appeared before a council of the gods to await sentence. In that long council were established the days and the nights, the seasons and the years, with the length thereof, and the sun was condemned to travel across the firmament by the same trail day after day till the end of time.

In this same philosophy we learn that in that ancient time a council of the gods was held to consider the propriety of making a moon, and at last the task was given to Whippoorwill, a god of the night, and a frog yielded himself a willing sacrifice for this purpose, and the Whippoorwill, by incantations, and other magical means, transformed the frog into the new moon. The truth of this origin of the moon is made evident to our very senses; for do we not see the frog riding the moon at night, and the moon is cold, because the frog from which it was made was cold?

The philosopher of Oraibi tells us that when the people ascended by means of the magical tree which constituted the ladder from the lower world to this, they found the firmament, the ceiling of this world, low down upon the earth—the floor of this world. Machito, one of their gods, raised the firmament on his shoulders to where it is now seen. Still the world was dark, as there was no sun, no moon, and no stars. So the people murmured because of the darkness and the cold. Machito said, "Bring me seven maidens," and they brought him seven maidens; and he said, "Bring me seven baskets of cotton-bolls," and they brought him seven baskets of cotton-bolls; and he taught the seven maidens to weave a magical fabric from the cotton, and when they had finished it he held it aloft, and the breeze carried it away toward the firmament, and in the twinkling of an eye it was transformed into a beautiful full-orbed moon, and the same breeze caught the remnants of flocculent cotton which the maidens had scattered during their work, and carried them aloft, and they were transformed into bright stars. But still it was cold, and the people murmured again, and Machito said, "Bring me seven buffalo-robes," and they brought him seven buffalo-robes, and from the densely matted hair of the robes he wove another wonderful fabric, which the storm carried away into the sky, and it was transformed into the full-orbed sun. Then Machito appointed times and seasons, and ways for the heavenly bodies, and the gods of the firmament have obeyed the injunctions of Machito from the day of their creation to the present.

The Norse philosopher tells us that Night and Day, each, has a horse and a car, and they drive successively one after the other around the world in twenty-four hours. Night rides first with her steed named Dew-hair, and every morning as he ends his course he bedews the earth with foam from his bit. The steed driven by Day is Shining-hair. All the sky and earth glisten with the light of his mane. Jarnved, the great iron-wood forest lying to the east of Midgard, is the abode of a race of witches. One monster witch is the mother of many sons in the form of wolves, two of which are Skol and Hate. Skol is the wolf that would devour the maiden Sun, and she daily flies from the maw of the terrible beast, and the moon-man flies from the wolf Hate.

The philosopher of Samos tells us that the earth is surrounded by hollow crystalline spheres set one within another, and all revolving at

different rates from east to west about the earth, and that the sun is set in one of these spheres and the moon in another.

The philosopher of civilization tells us that the sun is an incandescent globe, one of the millions afloat in space. About this globe the planets revolve, and the sun and planets and moons were formed from nebulous matter by the gradual segregation of their particles controlled by the laws of gravity, motion, and affinity. The sun, traveling by an appointed way across the heavens with the never-ending succession of day and night, and the ever-recurring train of seasons, is one of the subjects of every philosophy. Among all peoples, in all times, there is an explanation of these phenomena, but in the lowest stage, way down in savagery, how few the facts discerned, how vague the discriminations made, how superficial the resemblances by which the phenomena are classified! In this stage of culture, all the daily and monthly and yearly phenomena which come as the direct result of the movements of the heavenly bodies are interpreted as the doings of some one—some god acts. In civilization the philosopher presents us the science of astronomy with all its accumulated facts of magnitude, and weights, and orbits, and distances, and velocities—with all the nice discriminations of absolute, relative, and apparent motions; and all these facts he is endeavoring to classify in homologic categories, and the evolutions and revolutions of the heavenly bodies are explained as an orderly succession of events.

Rain.—The Shoshone philosopher believes the domed firmament to be ice, and surely it is the very color of ice, and he believes further that a monster serpent-god coils his huge back to the firmament and with his scales abrades its face and causes the ice-dust to fall upon the earth. In the winter-time it falls as snow, but in the summer-time it melts and falls as rain, and the Shoshone philosopher actually sees the serpent of the storm in the rainbow of many colors.

The Oraibi philosopher who lives in a *pueblo* is acquainted with architecture, and so his world is seven-storied. There is a world below and five worlds above this one. Muingwa, the rain-god who lives in the world immediately above, dips his great brush made of feathers of the birds of the heavens into the lakes of the skies and sprinkles the earth with refreshing rain for the irrigation of the crops tilled by these curious Indians who live on the cliffs of Arizona. In winter, Muningwa crushes the ice of the lakes of the heavens and scatters it over the earth, and we have a snow-fall.

The Hindoo philosopher says that the lightning-bearded Indra breaks the vessels that hold the waters of the skies with his thunderbolts, and the rains descend to irrigate the earth.

The philosopher of civilization expounds to us the methods by which the waters are evaporated from the land and the surface of the sea, and carried away by the winds, and gathered into clouds to be discharged again upon the earth, keeping up for ever that wonderful

circulation of water from the heavens to the earth, and from the earth to the heavens—that orderly succession of events in which the waters travel by river, by sea, and by cloud.

Rainbow.—In Shoshone, the rainbow is a beautiful serpent that abrades the firmament of ice to give us snow and rain. In Norse, the rainbow is the bridge Bifrost spanning the space between heaven and earth. In the Iliad, the rainbow is the goddess Iris, the messenger of the King of Olympus. In Hebrew, the rainbow is the witness to a covenant. In science, the rainbow is an analysis of white light into its constituent colors by the refraction of rain-drops.

Falling Stars.—In Ute, falling stars are the excrements of dirty little star-gods. In science—well, I do not know what falling stars are in science. I think they are cinders from the furnaces where the worlds are forged. You may call this mythologic or scientific, as you please.

Migration of Birds.—The Algonquin philosopher explains the migration of birds by relating the myth of the combat between Ka-bi-bo-no-ke and Shingapis, the prototype or progenitor of the water-hen, one of their animal gods. A fierce battle raged between Ka-bi-bo-no-ke and Shingapis, but the latter could not be conquered. All the birds were driven from the land but Shingapis; and then was it established that whenever in the future Winter-maker should come with his cold winds, fierce snows, and frozen waters, all the birds should leave for the south except Shingapis and his friends. So the birds that spend their winters north are called by the Algonquin philosophers "the friends of Shingapis."

In contrast to this explanation of the flight of birds may be placed the explanation of the modern evolutionist, who says that the birds migrate in quest of abundance of food and a genial climate, guided by an instinct of migration, which is an accumulation of inherited memories.

Diversity of Languages.—The Kaibabit philosopher accounts for the diversity of languages in this manner: Si-chom-pa Ma-so-its, the grandmother goddess of the sea, brought up mankind from beneath the waves in a sack, which she delivered to the Shi-nau-av brothers, the great wolf-gods of his mythology, and told them to carry it from the shores of the sea to the Kaibab Plateau, and then to open it; but they were by no means to open the package ere their arrival, lest some great disaster should befall. The curiosity of the younger Shi-nau-av overcame him, and he untied the sack and the people swarmed out; but the elder Shi-nau-av, the wiser god, ran back and closed the sack while yet not all the people had escaped, and they carried the sack, with its remaining contents, to the plateau, and there opened it. Those that remained in the sack found a beautiful land—a great plateau covered with mighty forests, through which elk, deer, and antelope roamed in abundance, and many mountain-sheep were found on the

bordering crags; *pive*, the nuts of the edible pine, they found on the foot-hills, and *use*, the fruit of the *yucca*, in sunny glades—and *nant*, the *meschal* crowns, for their feasts—and *chuar*, the cactus-apple, from which to make their wine; reeds grew about the lakes for their arrow-shafts; the rocks were full of flints for their barbs and knives, and away down in the cañon they found a pipe-stone quarry, and on the hills they found *arraumpive*, their tobacco. Oh, it was a beautiful land that was given to these, the favorites of the gods! The descendants of these people are the present Kaibabits of northern Arizona. Those who escaped by the way, through the wicked curiosity of the younger Shi-nau-av, scattered over the country and became Navajos, Moquis, Sioux, Comanches, Spaniards, Americans—poor, sorry fragments of people without the original language of the gods, and only able to talk in imperfect jargons.

The Hebrew philosopher tells us that on the plains of Shinar the people of the world were gathered to build a city and erect a tower the summit of which should reach above the waves of any flood Jehovah might send. But their tongues were confused as a punishment for their impiety.

The philosopher of science tells us that mankind was widely scattered over the earth anterior to the development of articulate speech, that the languages of which we are cognizant sprung from innumerable centers as each little tribe developed its own language, and that in the study of any language an orderly succession of events may be discovered in its evolution from a few simple holophrastic locutions to a complex language with a multiplicity of words and an elaborate grammatic structure, by the differentiation of the parts of speech and the integration of the sentence.

A Cough.—A man coughs. In explanation the Ute philosopher would tell us that an *unupits*—a pygmy spirit of evil—had entered the poor man's stomach, and he would charge the invalid with having whistled at night; for in their philosophy it is taught that if a man whistles at night, when the pygmy spirits are abroad, one is sure to go through the open door into the stomach, and the evidence of this disaster is found in the cough which the *unupits* causes. Then the evil spirit must be driven out, and the medicine-man stretches his patient on the ground and scarifies him with the claws of eagles from head to heel, and while performing the scarification a group of men and women stand about, forming a chorus, and medicine-man and chorus perform a fugue in gloomy ululation, for these wicked spirits will depart only by incantations and scarifications. In our folk-lore philosophy a cough is caused by a "cold," whatever that may be—a vague entity—that must be treated first according to the maxim "Feed a cold and starve a fever," and the "cold" is driven away by potations of bitter teas.

In our medical philosophy a cough may be the result of a clogging

of the pores of the skin, and is relieved by clearing those flues that carry away the waste products of vital combustion.

These illustrations are perhaps sufficient to exhibit the principal characteristics of the two methods of philosophy, and, though they cover but narrow fields, it should be remembered that every philosophy deals with the whole cosmos. An explanation of all things is sought —not alone the great movements of the heavens, or the phenomena that startle even the unthinking, but every particular which is observed. Abstractly, the plane of demarkation between the two methods of philosophy can be sharply drawn, but practically we find them strangely mixed; mythologic methods prevail in savagery and barbarism, and scientific methods prevail in civilization. Mythologic philosophies antedate scientific philosophies. The thaumaturgic phases of mythology are the embryonic stages of philosophy, science being the fully developed form. Without mythology there could be no science, as without childhood there could be no manhood, or without embryonic conditions there could be no ultimate forms.

III.—Mythologic Philosophy has Four Stages.

Mythologic philosophy is the subject with which we deal. Its method, as stated in general terms, is this: All phenomena of the outer objective world are interpreted by comparison with those of the inner subjective world. Whatever happens, some one does it—that some one has a will and works as he wills. The basis of the philosophy is personality. The persons who do the things which we observe in the phenomena of the universe are the gods of mythology—*the cosmos is a pantheon.* Under this system, whatever may be the phenomenon observed, the philosopher asks, "Who does it?" and "Why?" and the answer comes, "A god with his design." The winds blow, and the interrogatory is answered, "Æolus frees them from the cave to speed the ship of a friend, or destroy the vessel of a foe." The actors in mythologic philosophy are gods.

In the character of these gods four stages of philosophy may be discovered. In the lowest and earliest stage everything has life, everything is endowed with personality, will, and design: animals are endowed with all the wonderful attributes of mankind; all inanimate objects are believed to be animate; trees think and speak; stones have loves and hates; hills and mountains, springs and rivers, and all the bright stars, have life—everything discovered objectively by the senses is looked upon subjectively by the philosopher and endowed with all the attributes supposed to be inherent in himself. In this stage of philosophy everything is a god. Let us call it *hecastotheism.*

In the second stage men no longer attribute life indiscriminately to inanimate things; but the same powers and attributes recognized by subjective vision in man are attributed to the animals by which he is surrounded. No line of demarkation is drawn between man and

beast; all are great beings endowed with wonderful attributes. Let us call this stage *zoötheism*, when men worship beasts. All the phenomena of nature are the doings of these animal gods, all the facts of nature, all the phenomena of the known universe, all the institutions of humanity known to the philosophers of this stage, are accounted for in the mythologic history of these zoömorphic gods.

In the third stage a wide gulf is placed between man and the lower animals. The animal gods are dethroned, and the powers and phenomena of nature are personified and deified. Let us call this stage *physitheism*. The gods are strictly anthropomorphic, having the form as well as the mental, moral, and social attributes of men. Thus we have a god of the sun, a god of the moon, a god of the air, a god of dawn, and a deity of the night.

In the fourth stage, mental, moral, and social characteristics are personified and deified. Thus we have a god of war, a god of love, a god of revelry, a god of plenty, and like personages who preside over the institutions and occupations of mankind. Let us call this *psychotheism*. With the mental, moral, and social characteristics in these gods are associated the powers of nature; and they differ from nature-gods chiefly in that they have more distinct psychic characteristics.

Psychotheism, by the processes of mental integration, develops in one direction into monotheism, and in the other into pantheism. When the powers of nature are held predominant in the minds of the philosophers through whose cogitations this evolution of theism is carried on, pantheism, as the highest form of psychotheism, is the final result; but when the moral qualities are held in highest regard in the minds of the men in whom this process of evolution is carried on, *monotheism*, or a god whose essential characteristics are moral qualities, is the final product. The monotheistic god is not nature, but presides over and operates through nature. Psychotheism has long been recognized. All of the earlier literature of mankind treats largely of these gods, for it is an interesting fact that in the history of any civilized people, the evolution of psychotheism is approximately synchronous with the invention of an alphabet. In the earliest writings of the Egyptians, the Hindoos, and the Greeks, this stage is discovered, and Osiris, Indra, and Zeus are characteristic representatives. As psychotheism and written language appear together in the evolution of culture, this stage of theism is consciously or unconsciously a part of the theme of all written history.

The paleontologist, in studying the rocks of the hill and the cliffs of the mountain, discovers, in inanimate stones, the life-forms of the ancient earth. The geologist, in the study of the structure of valleys and mountains, discovers groups of facts that lead him to a knowledge of more ancient mountains and valleys and seas, of geographic features long ago buried, and followed by a new land with new mountains and valleys, and new seas. The philologist, in studying the earliest writ-

ings of a people, not only discovers the thoughts purposely recorded in those writings, but is able to go back in the history of the people many generations, and discover with even greater certainty the thoughts of the more ancient people who made the words. Thus the writings of the Greeks, the Hindoos, and the Egyptians, that give an account of their psychic gods, also contain a description of an earlier theism unconsciously recorded by the writers themselves. Psychotheism prevailed when the sentences were coined, physitheism when the words were coined. So the philologist discovers physitheism in all ancient literature. But the verity of that stage of philosophy does not rest alone upon the evidence derived from the study of fossil philosophies through the science of philology. In the folk-lore of every civilized people having a psychotheic philosophy, an earlier philosophy with nature-gods is discovered.

The different stages of philosophy which I have attempted to characterize have never been found in purity. We always observe different methods of explanation existing side by side, and the type of a philosophy is determined by the prevailing characteristics of its explanation of phenomena. Fragments of earlier are always found side by side with the greater body of the later philosophy. Man has never clothed himself in new garments of wisdom, but has for ever been patching the old, and the old and the new are blended in the same pattern, and thus we have atavism in philosophy. So in the study of any philosophy which has reached the psychotheic age, patches of the earlier philosophy are always seen. Ancient nature-gods are found to be living and associating with the supreme psychic deities. Thus in anthropological science there are three ways by which to go back in the history of any civilized people and learn of its barbaric physitheism. But of the verity of this stage we have further evidence. When Christianity was carried north from central Europe, the champions of the new philosophy, and its consequent religion, discovered, among those who dwelt by the glaciers of the north, a barbaric philosophy which they have preserved to history in the Eddas and Sagas, and Norse literature is full of a philosophy in a transition state, from physitheism to psychotheism; and, mark! the people discovered in this transition state were inventing an alphabet—they were carving Runes. Then a pure physitheism was discovered in the Aztec barbarism of Mexico, and elsewhere on the globe many people were found in that stage of culture to which this philosophy properly belongs. Thus the existence of physitheism as a stage of philosophy is abundantly attested. Comparative mythologists are agreed in recognizing these two stages. They might not agree to throw all of the higher and later philosophies into one group, as I have done, but all recognize the plane of demarkation between the higher and the lower groups as I have drawn it. Scholars, too, have come essentially to an agreement that physitheism is earlier and older than psychotheism. Perhaps there

may be left a "doubting Thomas" who believes that the highest stage of psychotheism—that is, monotheism—was the original basis for the philosophy of the world, and that all other forms are degeneracies from that primitive and perfect state. If there be such a man left, to him what I have to say about philosophy is blasphemy.

Again, all students of comparative philosophy, or comparative mythology, or comparative religion, as you may please to approach this subject from different points of view, recognize that there is something else; that there are philosophies, or mythologies, or religions, not included in the two great groups. All that something else has been vaguely called *fetichism*. I have divided it into two parts, *hecastotheism* and *zoötheism*. The verity of zoötheism as a stage of philosophy rests on abundant evidence. In psychotheism it appears as *devilism* in obedience to a well-known law of comparative theology, viz., that the gods of a lower and superseded stage of culture oftentimes become the devils of a higher stage. So in the very highest stages of psychotheism we find beast-devils. In Norse mythology, we have Fenris the wolf, and Jormungandur the serpent. Dragons appear in Greek mythology, the bull is an Egyptian god, a serpent is found in the Zendavesta; and was there not a scaly fellow in the garden of Eden? So common are these beast-demons in the higher mythologies that they are used in every literature as rhetorical figures. So we find, as a figure of speech, the great red dragon with seven heads and ten horns, with tail that with one brush sweeps away a third of the stars of heaven. And wherever we find nature-worship we find it accompanied with beast-worship. In the study of higher philosophies, having learned that lower philosophies often exist side by side with them, we might legitimately conclude that a philosophy based upon animal gods had existed previous to the development of physitheism; and philologic research leads to the same conclusion. But we are not left to base this conclusion upon an induction only, for in the examination of savage philosophies we actually discover zoötheism in all its proportions. Many of the Indians of North America, and many of South America, and many of the tribes of Africa, are found to be zoötheists. Their supreme gods are animals—tigers, bears, wolves, serpents, birds. Having discovered this, with a vast accumulation of evidence, we are enabled to carry philosophy back one stage beyond physitheism, and we can confidently assert that all of the philosophies of civilization have come up through these three stages.

And yet, there are fragments of philosophy discovered which are not zoötheistic, physitheistic, nor psychotheistic. What are they? We find running through all three stages of higher philosophy that phenomena are sometimes explained by regarding them as the acts of persons who do not belong to any of the classes of gods found in the higher stages. We find fragments of philosophy everywhere which seem to assume that all inanimate nature is animate: that mountains

and hills, and rivers and springs, that trees and grasses, that stones, and all fragments of things are endowed with life and with will, and act for a purpose. These fragments of philosophy lead to the discovery of hecastotheism. Philology also leads us back to that state when the animate and the inanimate were confounded, for the holophrastic roots into which words are finally resolved show us that all inanimate things were represented in language as actors. Such is the evidence on which we predicate the existence of hecastotheism as a veritable stage of philosophy. Unlike the three higher stages, it has no people extant on the face of the globe, known to be in this stage of culture. The philosophies of many of the lowest tribes of mankind are yet unknown, and hecastotheism may be discovered; but at the present time we are not warranted in saying that any tribe entertains this philosophy as its highest wisdom.

[*To be continued.*]

A HOME-MADE SPECTROSCOPE.

By JAMES J. FURNISS.

THE person to whom the study of spectroscopy is really attractive and congenial will not rest satisfied with mere reading, but, sooner or later, will experience a desire to possess a spectroscope of his own—to see for himself the phenomena which are described in the books. He who possesses and can spare the requisite means, will naturally provide himself with an instrument from the optician; but there are no doubt many who, while taking a great interest in this and kindred subjects, are so circumstanced that their outlay for scientific purposes must be limited to a very small sum. It is hoped that this article may be of some service to readers whose fortune places them in the latter category. I do not intend to say anything concerning the principles of spectrum analysis, or the construction and use of spectroscopes in general; that part of the subject may be studied in such treatises as "The Spectroscope and its Applications," by J. Norman Lockyer, or "The Spectroscope and its Work," by Richard A. Proctor, as well as in the more advanced works by Lockyer, Roscoe, and Schellen. I simply propose to give a few hints (which the works mentioned do not give), to enable the beginner, though he may possess little or no mechanical ingenuity, to construct at small expense an instrument which will prove a useful adjunct to his studies.

The chief quality to be desired is usefulness; the appearance of the instrument counts for little: if its performance be satisfactory, that is all that is necessary. The essential parts of the spectroscope are, (1)

the prism, (2) the collimator, (3) the telescope, and (4) the stand. The prism is the most important part of the instrument, and also the most expensive; but, as so much depends upon the performance of the prism, a good one obtained at the first will prevent the disappointment which inevitably follows the attempt to use a cheaper and less perfect article.

A hollow prism filled with a liquid such as oil of cassia, or bisulphide of carbon, may be used, or a flint-glass prism, or one of crown glass. A crown-glass prism may be procured for a comparatively small sum, but its dispersion is small, and to obtain really satisfactory results a train of three or more prisms is necessary, and such a number would be difficult for the beginner to handle without the automatic arrangement to be found in the regular instruments. The price of the hollow prism is a little higher than that of the crown-glass prism, but not quite so high as the price of one of flint glass; of its performance I know nothing by experience, but Lockyer does not speak very favorably of it. Perhaps on the whole the most satisfactory, and consequently in the end the cheapest article, is the flint-glass prism.

The collimator is a tube carrying at its outer end the slit, and at the end next the prism the collimating lens. The tube should consist of two pieces, one sliding easily within the other; so that the distance of the slit from the lens may be regulated. That distance should be equal to the focal length of the lens, in order that the rays of light passing through the slit in diverging pencils may be rendered parallel and sent through the prism as a cylindrical beam. Fig. 1 shows the collimator—*A* being the position of the slit, and *B* the position of the lens.

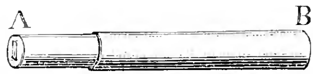


Fig. 1.

The focal length of the lens may be obtained near enough to give the approximate length of the collimator tube by projecting the image of some distant object sharply and distinctly on a screen, and then measuring the distance between the screen and lens. After the instrument is completed the adjustment of the lens and slit with regard to each other may be perfected by the following operation: Remove the prism, and bring the telescope, which must previously have been focused for distant objects, into line with the collimator; then move the sliding tube carrying the slit in or out until the image of the slit is seen sharply defined in the field of view of the telescope. The distance then between the slit and lens is equal to the focal length of the lens. The diameter of the lens need not be quite equal to the width of the refracting face of the prism. An ordinary convex lens of eight or ten inches focus, which may be purchased for a small sum, and which may easily be set in the tube by the student himself, will answer his purpose as well as a much more expensive article.

The figure of the slit is of great importance, and for fine work a

finished piece of mechanism with adjusting screw, etc., is necessary; but the beginner may content himself with an arrangement of much humbler pretensions. I have used a small plate of silver in which an opening (about three eighths of an inch long and one twentieth of an inch wide) had been cut, the width of the opening being reducible at pleasure by means of a little door or shutter sliding smoothly in grooves, and each opposing edge being faced with a strip of watch-spring. Fitted closely into the end of the tube is a piece of cork or wood having in its center a hole larger than the aperture in the slit plate; over this hole the slit plate is fastened, care being taken to stop up any accidental holes or crevices in the cork (or wood, as the case may be), in order to prevent the entry of extraneous light into the tube.

Primitive as this contrivance may appear, I have seen by its means, when using two flint-glass prisms, the *D* line of sodium double, and beautifully distinct. A slit, such as I have described, need not cost more than one tenth of the price charged for a slit by the optician.

Fig. 2 shows a slit of this kind open. *B* is the sliding shutter, and *A* is a piece soldered on the slit plate to bring the surface up level with *B*.

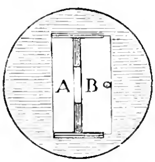


Fig. 2.

Concerning the observing telescope, perhaps Proctor's remarks about a finder for an astronomical telescope may be repeated: "It will be easy for the student to construct one for himself, and will be a useful exercise in optics." But in case the student may not want to take the trouble, he will be glad to remember that an ordinary pocket telescope or spy-glass may be purchased ready made for a dollar or two, and by removing the erecting lenses a small astronomical telescope may be produced which, as the magnifying power required is small, will answer every purpose of the beginner.

The stand may be made in a variety of styles, from the unpretending box on legs, with holes in the sides for the collimator and telescope, to the highly finished tripod of the most aristocratic-looking instrument. The following is one way of making a cheap and at the same time serviceable stand: Procure two disks of seasoned walnut or mahogany or any other hard wood, one about a foot in diameter by three eighths of an inch in thickness, and the other six inches by one quarter of an inch; also get two strips of wood about eight inches long and an inch and a half wide.

Make the larger disk into a table by screwing on three feet—metal hooks such as are used for hanging up clothes make excellent feet; then make a hole in the center of the large disk, and a corresponding hole in one end of each of the strips. Pass a screw downward through the two strips and through the hole in the disk, and let there be a thumb-nut on the screw so that it may be tightened underneath.

Fasten the lower strip of the two permanently to the disk, leaving the other strip free to move in an horizontal plane about the center of the disk. You will then have a stand like that represented in Fig. 3,

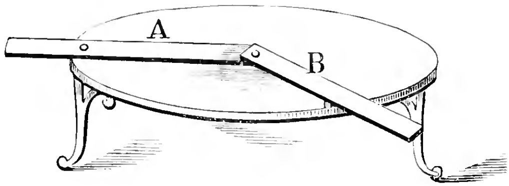


Fig. 3.

A being the stationary arm, and *B* the movable arm. Make the small disk of wood also into a table (see Fig. 4) by fastening in three sharp feet—screws will do. Place this smaller table centrally on the larger one, and it becomes the platform on which the prism is to stand. The next thing is to put the collimator and telescope in their places. For this purpose two small oblong blocks of wood are needed, each one having the upper part hollowed out into a groove to take—one the collimator, the other the telescope. (See Fig. 5, *d*, *d*.) The block carrying the collimator is placed on the stationary arm, and the one with the telescope on the arm which is free to move. Both are secured in their places by elastic bands. The blocks of wood must necessarily be of such a height that the axis of their respective tubes (collimator and telescope) may be brought into alignment (1) with

Fig. 4.

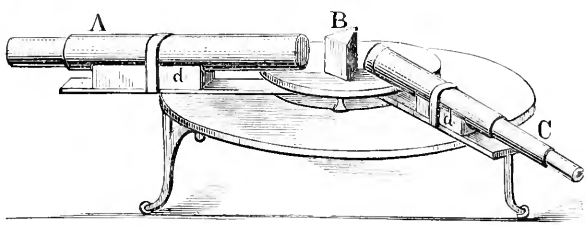


Fig. 5.

each other, and (2) with the prism. The instrument is then complete (see Fig. 5), where *A* is the collimator, *B* the prism, and *C* the telescope.

The manner of using the spectroscope has been described in such works as those I have already mentioned, and does not properly belong to an article such as this, but perhaps a few hints as to the adjustment of the instrument may not come amiss to the beginner. The

angular position of the prism, with regard to the collimator, is a matter of importance, the distinctness and purity of the spectrum depending in a great measure on that position. Perhaps as good a way as any is to find by actual trial the angular position of the prism which gives the best results, thus: Focus the telescope for distant vision, align the telescope with the collimator, and move the slit till it (the slit) is seen distinctly in the telescope; then put the prism in place approximately, and move it round its axis until a position is found where (supposing the light of the sun or diffused daylight to be under examination) the lines in the green part of the spectrum are seen at their best advantage. It must be remembered that a slight change of focus is necessary for every color. When the bounding edges of the ribbon of variegated light which forms the spectrum are seen sharply defined at the same time that the lines across the spectrum are distinct, the adjustment is pretty correct; when such is not the case, the slit and lens are not in their proper relative positions. The narrower the slit, consistent with the necessary supply of light, the finer and more distinct are the lines. A black cloth, or a pasteboard box, with suitable apertures for the collimator and telescope tubes, should be placed over the prism to shut out all extraneous light. In conclusion, I must remark that I do not pretend to describe an instrument capable of doing exact or delicate work. My aim is simply to show with how little trouble or ingenuity a spectroscope may be put together which will help materially those students who wish to obtain a good general idea of a branch of science which has done more to unravel the mysteries of nature than any other inquiry with which the human mind has ever been occupied.

THE SOURCE OF MUSCULAR POWER.

By H. P. ARMSBY.

THE question of the source of muscular power is essentially a question concerning transformation of energy. The most characteristic distinction between plants and animals is, that the former appropriate force from outside themselves, from sunlight, and store it up as potential energy in the various complex compounds which they form in; while animals draw their supplies of force entirely from those compounds in which it has been stored up by plants, and from which it is set free again when they are decomposed in the organism.

In a word, the plant converts the actual energy of the sunlight into the potential energy of organic compounds, the animal converts the potential energy of the organic compounds into actual energy, which manifests itself as heat, motion, electricity, etc.; in the plant the spring is coiled up, in the animal it uncoils, exerting an amount of

energy equivalent to that which coiled it. One of the forms which this energy takes on is that of muscular motion, which we thus trace back to the potential energy of food, and through this to that great source of all energy to our earth, the sun.

We are not, however, satisfied with knowing in this general way that it is the food we eat which serves as a vehicle to convey to us our needful supply of sun-force. We were already acquainted with the necessity for food, but we wish to know which of the ingredients of our food performs this function, or, if all do it, which one performs it to the best advantage.

Until a comparatively recent date it was assumed unhesitatingly that the albuminoids—that is, bodies like albumen (white of egg), fibrine (muscular fiber), caseine (the basis of cheese), etc., which contain the element nitrogen as a characteristic ingredient, and which we shall designate collectively as proteine—were the proximate source of muscular power. It was taught that work was performed by means of an increased oxidation of the fibrine, of which the muscles are largely composed, and that the proteine of the food served to repair the wear thus caused. This view is still found in many especially of the smaller text-books of physiology, and seems to be the one generally current. Even so eminent a physiologist as Professor Austin Flint, Jr., has recently devoted a small book ("The Source of Muscular Power," D. Appleton & Co., 1878) to its defense; but nevertheless it was never founded upon experimental evidence, and has now been rendered untenable in its original form.

Karl Voit, of Munich, was the first to make exact experiments on this subject, and in 1860 he published the results of his researches, which showed conclusively that, contrary to the then generally accepted theory, muscular exertion did not increase in the least the amount of proteine decomposed in the body, although it *was* accompanied by a large increase in the amount of non-nitrogenous matters oxidized. This fact was immediately accepted by many physiologists as a proof that the commonly received view of the source of muscular power was incorrect, and that that power was in reality derived from the non-nitrogenous components of food—its fat, starch, sugar, etc. According to them, the muscles are, like a steam-engine, simply an apparatus for the transmission of energy furnished by some other substance, while the fat, etc., is the fuel of the living machine.

Voit and his followers, on the contrary, still hold that proteine is the proximate source of muscular power, though their views have naturally been materially modified by the experimental results just mentioned.

Voit compares the constant decomposition of proteine which goes on in the body to the constant flow of water in a stream. A mill situated by the stream may use the whole power of the water, a half, a quarter, or any desired fraction, without in the least altering the

amount of water running past. So in the body the decomposition of proteine, which is the source of power to the muscles, goes on constantly, independently of whether the energy which is set free takes the form of motion or appears in some other shape.

These are, in outline, the views of the two schools into which physiologists are divided upon this point. Professor Flint, in his book already referred to, advocates, and seeks to sustain by experimental evidence, a theory which may fairly be said to have been abandoned by both sides; and a review of his book, which appeared in this journal in April, 1878, having given some prominence to the subject, a brief review of the present state of our knowledge upon it may not be uninteresting.

It will facilitate an intelligent comprehension of the matter to preface our study of the main question with some explanation of the means by which our knowledge of the amount of nitrogenous and non-nitrogenous matter decomposed in the body is gained, and by some considerations regarding the effect of the kind and quantity of food upon the nutrition of the muscular system and the excretion of nitrogen.

The animal body may for our present purpose be regarded as consisting, besides water, of proteine and non-nitrogenous matter, chiefly fat: the latter contains the elements carbon, hydrogen, and oxygen; the former, in addition to these three, nitrogen. Both classes of matter are gradually oxidized in the body, and are finally converted into carbonic acid, water, and urea, the former of which is excreted through the lungs and skin, the latter through the kidneys, and the water partly by all three channels.

In the urea (together with small amounts of uric acid and other products) is contained the nitrogen resulting from the oxidization of the proteine.

It has been established, by an overwhelming mass of evidence, that all the nitrogen which leaves the system does so in the urine, and that the amount of this element in the latter is an accurate measure of the amount of proteine destroyed in the body. A determination of ureal nitrogen thus informs us of the amount of albuminoids oxidized; while a determination of the amount of carbon excreted in carbonic acid and urea, taken together, enables us, by a little calculation, to find the amount of fat oxidized.

By means of experiments conducted on this basis a tolerably full knowledge has been obtained of the effect of food upon the formation of flesh (muscular substance) and fat, and facts have been discovered which have an important bearing, both on our views of the origin of muscular power and on the precautions necessary in experimenting upon this subject. The earliest workers in this field were Bidder and Schmidt, followed by Karl Voit, in conjunction, first with Bischoff and later with Pettenkofer.

One result of these researches has been to demonstrate that *the consumption of proteine in the body is determined by the amount of it present in the food.* If the food contains but little proteine, but little is oxidized in the body ; if more be added, the consumption of it in the vital processes promptly increases, and within at the most three or four days comes into equilibrium with the supply, or very nearly so.*

Another important point is the distinction, first introduced by Voit, between what he calls circulatory and organized proteine. He has shown, by experiments which it would take too much space to describe, that the proteine of the body exists in two states : first, as organized proteine, which is comparatively stable ; and, second, circulatory proteine, which exists in much smaller amount than the other, and undergoes a much more rapid decomposition in the body. The first effect of albuminoids in the food is to increase the amount of this circulatory proteine and the rapidity of its decomposition, and it is in this way that the consumption of proteine in the body is, as has just been stated, determined by the supply of albuminoids in the food. The production of organized proteine, which Voit supposes to constitute the muscular tissue, is, on the contrary, much less rapid, it being slowly formed from the circulatory proteine under proper conditions.

Some authorities dispute the correctness of the names circulatory and organized proteine, but there is no dispute as to the fact, shown by his experiments, that most of the proteine of the body exists in a comparatively stable form, while a small portion, dependent in amount upon the supply in the food, is being continually and rapidly oxidized and furnishes most of the nitrogen eliminated through the kidneys. We might compare the stock of circulatory albuminoids in the body to a mass of water contained in a vessel with a small aperture in the bottom. If there is no supply, it quickly runs out. If a small stream of water be let in at the top, a small supply of water may be maintained in the vessel. If a larger stream be admitted, the depth of water in the vessel will at once begin to increase, but at the same time the pressure on the bottom, and consequently the rapidity of the outward flow through the aperture, increases, and outflow and inflow soon come into equilibrium. If the supply be diminished, the level of the water sinks till the hydrostatic pressure causes the outflow to again equal the inflow.

Voit's results have been abundantly confirmed by other observers in experiments on various animals, including man, and must be regarded as fully established, whatever view we may take of the interpretation put upon them by their author. In Professor Flint's book, however, we fail to find any reference to these discoveries, though they have, as we shall see, a most important bearing on his own experiments. He does, indeed, mention the similar but less complete results

* Voit's experiments were made on dogs. With herbivorous animals the same law holds, but the change is not so rapid.

of Lehmann (p. 35), and states (p. 41) that "the change of the normal diet to a regimen of non-nitrogenous matters alone of itself diminishes very largely the excretion of nitrogen"; but the more recent results of Voit and others are passed over in silence, though on pages 26–28 he mentions some facts and introduces some considerations which go to show the correctness of these results.

Coming now to the main question, we follow the general order of Professor Flint's book, and consider, first, the effect of muscular exertion upon the metamorphosis of matter in the body as shown by the excretions, and, second, the conclusions which can be drawn from these effects as to the proximate source of muscular power.

According to Professor Flint (p. 40), the experiments of Fick and Wislicenus in 1866 constituted "the starting-point of the new theory of the origin of muscular power." This, however, can hardly be said to be the case, at least as regards the experimental evidence on which that theory is based. We have already stated that Voit was the first to seek for evidence of the truth of the views held by his predecessors, and his experiments, as also those of E. Smith, antedate those of Fick and Wislicenus by some six years. Not only so, but the theory itself had been broached before Fick and Wislicenus made their experiments, as may be seen from their paper on the subject. At the same time their results gave it a powerful impulse and won for it more general attention.

Voit's conclusions have been fully corroborated by numerous and able investigators,* and are at present accepted by the great majority of physiologists; and we naturally expect some reference to them in a critical discussion of this question. We find, however, no mention of them; we are left to infer that the experiments of Fick and Wislicenus are the chief basis for the conclusion that work does not increase the elimination of nitrogen in the urine, and the author enters into a criticism of these experiments which is groundless, since it mistakes entirely their object.

The experiments of Fick and Wislicenus were not designed to show that work did not increase the destruction of proteine in the organism, but that the latent energy of the amount destroyed was insufficient to account for the work done. For this purpose they ascended an Alpine peak of known height, carefully determined the amount of nitrogen excreted during the ascent, and calculated from this the amount of proteine destroyed. Their diet before and during the performance of the work contained no proteine. On reckoning the amount of latent energy contained in the proteine destroyed, as shown by the quantity of heat which it would have yielded if burned, they found this energy

* Among these confirmatory results may be mentioned, as having historical as well as scientific interest, those obtained in 1867 by T. R. Noyes, M. D. ("American Journal of Medical Science," October, 1867), then a student in the Yale Medical School, which in the main agreed with those of Voit.

to be insufficient to raise the weight of their bodies to the height of the mountain, and hence they conclude that the lacking energy at least must have been derived from non-nitrogenous materials.

Their experiments were well designed for the purpose intended, and the criticisms of Professor Flint (pp. 40–43) that the decrease in the excretion of nitrogen during and immediately after the work was due to the abstinence from albuminoid food, and that no comparison of rest with work was made, while doubtless well founded, do not touch the point at issue, viz., that a certain amount of work was performed and a certain amount of proteine destroyed, and that the latter was not, according to their calculations, sufficient to yield the amount of force actually exerted. The only grounds upon which the validity of their results can be successfully disputed are either that the principle of calculation employed by them or their data as to the heat of combustion of proteine were erroneous. We shall return to this point later. It may be added, in regard to the experiments of Voit and the other investigators in this field, that they are free from the failings which Professor Flint finds in those of Fick and Wislicenus, and also of Parkes.

The experiments of Dr. Parkes, which Professor Flint apparently regards as at least partially sustaining the view which he advocates, show in the great majority of cases either no increase or a slight decrease of the excretion of nitrogen as a consequence of work, and Dr. Parkes himself expressly says ("Journal of the Royal Society," vol. xix., p. 349): "The result of both series was, so far, to confirm the experiments, which show that the changes in the nitrogen of the urine . . . are small in extent, and afford no measure of the work."

Professor Flint's chief reliance, however, seems to be the experiments made in 1876 by Dr. Pavy, and published in a series of papers in "The Lancet," and his own experiments made in 1870 ("New York Medical Journal," June, 1871).

These two series of experiments differ decidedly, both in method and results, from those heretofore mentioned, both of them showing, according to their authors, an increased elimination of nitrogen through the kidneys as a result of muscular exertion. They were made upon two pedestrians, Perkins and Weston, during the performance of various feats of pedestrianism, and hence under conditions that excluded an exact measurement of the amount of work performed. Unfortunately, also, they could not, from the nature of the case, be made with that rigorous control of all the conditions of experiment which is essential in such researches; and they suffer under various sources of inaccuracy which materially lessen their value.

In the first place, no attempt was made to regulate the diet of the two men; they ate what and when they chose. In most experiments on this subject it has been considered necessary to employ a perfectly uniform diet as regards nitrogen, and an instructive example of the pains taken to insure it may be found in a paper by Voit and Petten-

kofer in the "Zeitschrift für Biologie" (1866, p. 466). In the case before us, however, the investigators contented themselves with weighing the food eaten and estimating its contents of nitrogen. We have seen that Professor Flint elsewhere insists upon the importance of the food eaten in its effects on the excretion of nitrogen, but, both in his own experiments and Dr. Pavy's, there were, according to their own estimates, great variations in the amount of nitrogen ingested from day to day, as, for example, 65·68 grains and 161·72 grains, or, on another occasion, 522·42 grains and 871·92 grains on two successive days in Dr. Pavy's experiments, and 144·70 grains and 383·04 grains in Professor Flint's.

Such great and sudden variations as these could not but impair the accuracy of the experiments, and cause corresponding fluctuations in the amount of nitrogen excreted, as has been sufficiently shown by the investigations of Voit and others already alluded to, and the results bear testimony that such was the case.

Furthermore, not only did the quantity of nitrogen ingested from day to day vary, but even these varying amounts were not accurately determined by analysis, but simply, with a few unimportant exceptions, estimated from the average composition of similar articles as given by Payen. Neither Dr. Pavy nor Professor Flint appears to have even taken the trouble to estimate the water of the various articles of food, but to have simply weighed them in the fresh state—a fact which alone deprives the results of all claim to strict accuracy, since the water content of such articles as fresh meat or bread, for example, is quite variable, and the proportion of nitrogen in the fresh substance of course varies correspondingly. While such a method may give an approximation to the truth, it is impossible that, when applied to such a varied diet as that taken in these experiments, it should give results of scientific exactness.

The estimations of the ureal nitrogen appear to have been made after approved methods, and are to be assumed to be correct; but, even if we assume the accuracy of the estimates of nitrogen in the food as well, the results of Dr. Pavy do not show what he claims for them. They do, indeed, show that there was an increase in the average daily excretion of nitrogen during work over that during rest of 194·12 grains, and, at the same time, an increase of 201·63 grains in the average amount of nitrogen daily ingested. The only conclusion which can be drawn from these figures is, that during work more nitrogen was excreted *because more was taken in the food.* That muscular exertion caused any increase in the excretion of nitrogen we have no evidence.

With Professor Flint's experiments the case is somewhat different. There the amount of proteine taken in the food was considerably less during work than during rest, while the excretion of nitrogen remained about the same, so that the *relative* excretion was increased.

This, Professor Flint claims, shows that the work performed was accomplished at the expense of muscular tissue, which was destroyed and caused the increase in the relative excretion.

Were the data as to food more exact, this might be the case; but, as it is, the result seems to need further confirmation before it can be accepted.

The only other similar result, so far as we know, is one recently obtained by E. von Wolff in experiments on the horse; but, having access only to a brief abstract, we are unable to judge of the accuracy of the work, though from the high reputation of this investigator it is to be assumed that it was executed with every precaution. It was found that an increase of the work performed was accompanied by an increased excretion of nitrogen in the urine; but the author reserves the details of his experiments till further observations shall have confirmed or disproved their results, and at present, until the subject has been more thoroughly investigated, we must follow the preponderance of evidence, which is most decidedly in favor of Voit's result, viz., that work does not increase the destruction of proteine in the body and the consequent excretion of nitrogen through the kidneys.

Thus far we have simply been considering experimental results, without regard to the conclusions to be drawn from them; we now come to their interpretation, and here it must be admitted, at the outset, that the data now at command are not sufficient to enable us to solve the problem of the source of muscular power. But, though we do not know precisely what the proximate source of muscular power is, we are able to indicate with tolerable certainty the direction in which an answer to this question is to be sought, and to say that certain conclusions have a high degree of probability.

It would seem at first thought that if, during work, the oxidation of non-nitrogenous matters in the body increases, while no more proteine is destroyed than during rest, the non-nitrogenous matters must be the source of the power exerted. This appears to be Professor Flint's view, as indicated by several passages in his book; but, though it may be a *probable* conclusion, it is by no means a *necessary* one. We have already mentioned the fact that Voit and his followers still consider the constant decomposition of circulatory proteine which goes on in the body to be the source of muscular power, comparing it to a constantly flowing stream, the energy of which may be converted at will into motion, or be allowed to take the form of heat; and there is nothing in the experimental results above adduced to forbid this interpretation.

It has been shown by Voit and Pettenkofer to be at least very probable that proteine in its decomposition in the body takes up the elements of water and splits up into urea and *fat*; and it is easy to show by calculation that 100 parts of proteine could produce in this way 51·4 parts of fat. This process, now, takes place during rest, and it is quite con-

ceivable that during work the proteine is decomposed completely into carbonic acid, water, and urea, and that thus the latent energy which would otherwise be stored up in the fat is applied to the production of motion. If this were shown to be the case (and it seems not improbable that something similar to it actually takes place), it would become largely a question of nomenclature whether we should regard the proteine or the fat which is formed from it as the source of muscular power. For ourselves, we believe that the truth will eventually be found to lie between the two extreme views now advocated, and that muscular force will prove to have some such origin as that above indicated.

At the same time there are certain facts immediately to be considered which show that the process is by no means so simple as that just sketched.

If we turn from the study of the effects of muscular exertion to that of its conditions, we shall get much new light, and be helped to a more rational judgment of the theories as to its source. Presupposing the existence of a healthy and well-developed organism, we may specify *four* conditions as, from our point of view, the most important:

1. The facts of common experience appear to show unmistakably that a liberal supply of proteine in the food is one of the conditions of any sustained muscular exertion. This, however, does not necessitate the conclusion that the proteine is the source of the power exerted: its decomposition, as we have seen, goes on independently of muscular exertion, and may be regarded as simply one of the conditions of the healthy activity of the muscles.

2. The largely increased excretion of carbonic acid and water during work indicates a necessity for a liberal supply also of the non-nitrogenous constituents of food. At need, however, this demand may be supplied by the albuminoids of the latter, or perhaps by fat already formed in the body.

3. An essential condition of continued activity of the muscles is the constant removal from them by the circulation of the chemical products of their action. Certain of these products, notably lactic acid and acid potassium phosphate, if allowed to accumulate in the muscle, produce the sensation of weariness, and shortly incapacitate it for further action. If they be removed, either by the blood or by injection of a weak salt solution, the muscle is again capable of work; while, if they be injected into a fresh muscle, they produce the same effect as if naturally formed there. The same or similar processes go on in the muscle after death, and the *rigor mortis* is caused by the solidification of the jelly-like *myosin*, which is also one of the products of the action.

4. A most important condition of muscular activity is found in the capacity which the body has to store up oxygen in itself during sleep, to be used later in the waking hours. This capacity was discovered by Voit and Pettenkofer in experiments on men, and has been con-

firmed by Henneberg's experiments on oxen. More carbonic acid is excreted by day than by night, since more work is then done. But at the same time *less* oxygen is taken into the body in the daytime than during the night. For example, in one of Voit and Pettenkofer's experiments, for every 100 parts of oxygen which entered the system in the daytime 175 parts were contained in the carbonic acid excreted, while in the night the same relation was expressed by the number 58. When work was performed the difference was still greater. This and similar experiments show plainly that a large part of the carbonic acid excreted is formed at the cost of oxygen previously laid up in reserve, and that the increased rapidity of respiration during work is not for the purpose of supplying more oxygen, but of removing the carbonic acid.

It has been also shown that the amount of oxygen that can thus be stored up in health is proportioned to the amount of albuminoids in the food, and this is another indication of the importance of these bodies in the production of muscular power.

The necessity of this storing up of oxygen is strikingly shown by experiments on two diseases in which the patient is almost incapable of muscular exertion, viz., diabetes mellitus and leukæmia lienalis. In these diseases the total excretion and the total amount of food are not much different from those in health; but there is no such storing up of oxygen as in the healthy organism, and there is also an almost entire lack of strength.

This fourth condition is, for our present purpose, the most interesting and important of all. It shows that work is not produced by the direct oxidation of food materials by the oxygen of the blood, but that the muscles themselves contain a store of latent energy which the will can set free at pleasure, independently of oxygen, while the blood serves to wash out the waste products and gradually to renew the supply of force during those periods of rest of which this fact explains the necessity.

That the seat of this latent energy is in the muscles is shown by the fact that they are capable of contraction for a time after their blood-supply has been cut off, or even after their removal from the body. A frog's heart, when removed from the body and freed from all blood by injection of a weak solution of salt, will continue to beat for hours, and the whole animal under the same circumstances moves, leaps, and behaves in short like a living animal. Agassiz relates that on one occasion he captured a shark which fought as long and fiercely as is usual with these animals, but which, when finally secured, was found to have its gills eaten through by parasites, and almost all its blood replaced by sea-water. (Liebig.)

Like a bent spring the muscle contains a certain amount of potential energy, which the will can use at pleasure; but when the supply is once exhausted, when the spring has lost its tension, a further supply of force from without is necessary before more work can be performed.

These facts furnish an important clew to the source of muscular power. The experiments of Voit and Pettenkofer show that while storing up oxygen during rest the organism is laying up a store of force to be used later; while those of Henneberg connect this storing up of oxygen with the supply of albuminoids in the food, and render it highly probable that it is accomplished by their means.

Two hypotheses as to the function of the albuminoids as agents in the production of muscular power at once suggest themselves. The first is, that they simply serve as reservoirs of oxygen, which latter is used at will to burn the non-nitrogenous parts of the food, the result being work, heat, and an increased excretion of carbonic acid and water. This would be the view of those who consider the carbhydrates and fats as the source of muscular power, and its simplicity renders it attractive. It must be noted, however, that it requires us to look upon the non-nitrogenous materials oxidized as part of the muscle, since the latter can perform work independently of the circulation of blood through it.

A second hypothesis, however, less simple and easily grasped than the first, is considered by many high authorities to accord more closely with the facts of the case and with our general conceptions of vital activity.

This hypothesis supposes that during rest some of the substances of the muscle-cells decompose into simpler compounds, and in so doing set free their latent energy, which energy, instead of appearing as heat, etc., is used to build up out of other constituents of the cell a still more complex compound containing more potential energy than its components, just as one portion of society may acquire wealth at the expense of another portion, with no increase of the total wealth of the community.

The substances which are thus "synthesized" are proteine, an unknown non-nitrogenous matter from the blood and oxygen; the hypothetical compound thus formed accumulates to a certain extent in the muscle, and, when the latter is called on to perform work, splits up, yielding carbonic acid, water, and other non-nitrogenous matters, and proteine or some similar compound, and giving forth the amount of force which was required to form it. The non-nitrogenous substances which are formed are supposed to be rapidly excreted; while the nitrogenous product, instead of undergoing further decomposition, is used over again to re-form the hypothetical substance.

This view has much in its favor. Various syntheses like that above outlined are known to take place in the body; and, moreover, all the facts seem to indicate that muscular force originates in a splitting up of some substance in the muscle, accompanied by the liberation of force, rather than by any process of oxidation in the ordinary sense of the word.

The hypothesis explains the object of the storing up of oxygen in

the body during rest, and its connection with the laying up of a reserve of force: the oxygen enters into the supposed complex compound much as the nitric-acid radicle enters into nitro-glycerine or gun-cotton—it is held in a state of unstable equilibrium, ready to enter into new and simpler relations with its neighboring atoms, and to set free the force by which it was placed in its unstable position. The hypothesis explains also that necessity for albuminoids in the food of the laboring animal which practical experience has shown to exist, as well as the fact that there is no greater excretion of nitrogen during work than during rest; the proteine serves as the basis for the alternate synthesis and analysis which constitute what might be called the atomic mechanism of muscular activity without itself being destroyed. Furthermore, it shows why we need rest after work; in the first place, the circulation must have an opportunity to remove those waste products which accumulate in the working muscle faster than they can be carried off, and in the second place a fresh supply of force must be stored up in the way described before it is ready to be used at the command of the will.

Thus this theory explains all the facts now known, and, while it is but an hypothesis, it is still based on the "scientific use of the imagination," and indicates the direction in which we may confidently look for an advance of positive knowledge.

If it be true, much of the current discussion upon the source of muscular power is but a "strife of tongues"; both proteine and non-nitrogenous substance are necessary, and an inquiry as to which is the source of the power would resemble an inquiry as to whether the explosive force of nitro-glycerine was derived from the glycerine or the nitric acid used in its manufacture, and would be a question of metaphysics rather than of natural science.

It might be asked, since this is a question of transformation of energy, why we do not apply the law of the conservation of energy, and from the heat of combustion of the various elements of food calculate their value as reservoirs of force by Joule's formula. This has been frequently attempted, notably by Fick and Wislicenus in their experiments already alluded to. These investigators showed that the amount of force contained in the proteine which was destroyed in their bodies during the ascent of the Faulhorn was insufficient, if wholly converted into motion, to raise their bodies to the height of the mountain.

Various other attempts at the same sort of calculation have been made, with more or less of care and insight: we may mention here those of Dr. Pavy, which rest on several assumptions of questionable accuracy; and those of Professor Flint, made upon the same plan, with the object of showing the worthlessness of Dr. Pavy's—an object which he has doubtless attained.

It would carry us too far to discuss here the value of these results,

and we must content ourselves with two general statements: 1. The heats of combustion of the various food-substances, which serve as the foundation of all such calculations, have not yet been determined with sufficient accuracy to render those calculations demonstrative. 2. Even if it were shown that the results of Fick and Wislicenus are correct, and that the albuminoids destroyed during work are not sufficient to supply all the force exerted, this in no way invalidates our hypothesis, since the latter does not place the source of muscular power in the albuminoids alone, but in the joint action of these and of non-nitrogenous matters.

It will be seen that the foregoing views as to the origin of muscular power are in some respects in substantial accordance with those of Professor Flint. Like him we hold that the source of muscular power is to be sought in the muscles themselves, and not in any burning of the constituents of the food in the blood or the juices of the body. Muscular power, we believe, does not have its immediate origin in oxidation but in the splitting up of an unstable compound into simpler ones.

We differ from him, however, both in regard to the effect of muscular activity upon the destruction of proteine in the body and in regard to the conclusions to be drawn from these effects. Professor Flint claims that work increases the amount of proteine destroyed; we believe we have shown that neither his own experiments nor those of Dr. Pavy are sufficient to prove this, and that the preponderance of evidence is altogether in the other direction.

He says further (p. 31): "In other words, is the muscular substance an apparatus for transforming the force locked up in food into power, or are the muscles themselves consumed, the elements of food being used for their repair? These questions may be resolved by little more than a single experimental line of inquiry: Does physiological exercise of the muscular system increase the elimination of nitrogenized excrementitious principles?"

Were these questions capable of being resolved in this simple manner, their answer would be just the reverse of that which Professor Flint gives to them; but we have already seen that such researches are entirely inadequate, of themselves, to settle the matter, and that very different considerations must be attended to in order to attain that end.

Some of these considerations we have endeavored to present, as clearly as might be, in the foregoing pages, while pointing out what seems to us the false method by which Professor Flint, in his very interesting book, has sought to maintain a conclusion which itself is doubtless correct, viz., that muscular power originates in vital actions taking place in the cells of the muscles themselves and not in a simple oxidation of food-constituents. We can not but regret that this fact, which he so clearly appreciates and states, should be supported

by invalid reasoning, and that the sanction of a name so eminent among American physiologists should be given to views which do not accord with the results of the best and most recent investigations on this subject.

THE RESULTS OF ABSTRACTION IN SCIENCE.

By CHARLES T. HAVILAND.

THE old scholastic controversy as to the reality of universals has its analogue in modern times. Formerly the strife had its religious implications, and it was from the arsenal of theology that the defenders of realism procured their weapons. Theological realism has now been virtually abandoned, and it is to metaphysics that the realists appeal to defend their abstractions from the searching analysis to which scientific modes of thought would most assuredly subject them.

Realism was the doctrine that universals have a real existence, entirely independent of the concretes from which they were generalized. It was held, for instance, by the older realists, that there is in the universe a perfect circle, freed from the imperfections of those we are able to construct; that this is not an idea generalized from the circles we see; that it is not the result of abstracting the imperfections that are inseparable from any circle we can draw and confining our attention alone to its perfections; but that there really exists an archetype of which circles as we know them are merely imperfect reproductions. This doctrine, even among the scholastics, found its strong opponents, and in its cruder forms was obliged to succumb. In metaphysics, however, realism, in a more refined form, found a soil fitted to its luxuriant growth, and the belief in entities and quiddities, and the other metaphysical essences associated with these, spread to such an extent that the successive influences of men as powerful as Locke and Hume sufficed to check rather than to exterminate it. The scientific tendency of thought, in which these men were pioneers, is now making havoc among the heirlooms of a past civilization. This tendency, which accepts nothing on mere assertion, and which forces every belief to produce its credentials, is now bringing its methods to bear upon the entities of metaphysics, and proving conclusively that they are of no nobler descent than the phenomena in which they originated.

The decadence of realism affords so striking an example of the general change in the conception of nature that has taken place within the past three centuries as, to a certain extent, to justify Comte's generalization as to the natural development of thought. There could, historically, hardly be a better example of this change than in the con-

sideration of the decline of the theological and metaphysical conceptions of nature and the abstractions that grow out of them.

All the recent advances in ethnology teach us that man, as far back as we can trace his beliefs, explained the universe by the only power that he knew—that which he was himself conscious of possessing. To him every manifestation of power was the act of some god or demon who inhabited the sun, the moon, the forests, or the waters, and whose vengeance (for the primitive man's faith in diabolical agencies might well shame the believers in the more sublimated theories in regard to that cheerful dogma at the present day) it was necessary to placate by offerings, by sacrifices, by penances, and by supplications. No adequate test of reality then existed, and the spirit of a dream was as truly materialized as anything that could not be subjected to those most "realizing" of all senses—touch and muscular power.

The whole history of fetiches, idolatry, and polytheistic religions generally shows how strong was the belief in the immanence of powers beyond the human. An increase of culture served to remove the home of the gods to more distant fields, and, as man learned to philosophize, metaphysics gradually encroached on theology. The ideas of Plato, which to him were as real as the fetiches to the savages, were, as abstractions, the metaphysical substitutes for the demons that had preceded them.

The contest of nominalism with realism, which, during the middle ages, waxed so hard, paved the way for the scientific—or, in the Comtean terminology, the positive—conception of nature. Discerning in a great class of phenomena the evident progress of thought, Comte was led to suggest his famous law. As certainly as it has been disproved as a general law that thought passes from the theological, through the metaphysical, to the positive stage, so certainly has this theory a sort of broad suggestiveness, which often leads to otherwise undiscovered truths. The odium naturally and justly attaching to Comte's later social theories has had the tendency to obscure the value of his philosophical speculations. It is a fault (if it be a fault) of all founders of systems to over-estimate the application of their theories. Impressed by the discovery of a new truth, what wonder if they group all things under their rubric, and leave to their followers the task of clearly defining its application? Although in his constructive theories Comte erred most fatally, yet the fertility of his suggestions gave a great impetus to a more scientific philosophy, and extended its bounds over hitherto untrodden fields. Many owe to him much more than they willingly admit—more than they themselves are conscious of; and his uncompromising nominalism has had the tendency more precisely to define the meaning of abstract terms, and clear philosophy, and through it science, of much metaphysical verbiage.

While thus scientific nominalism is clearly in the ascendancy, there is a certain phase of realism which enters so completely into many

scientific discussions, and has such a broad bearing upon their decision, that it may well claim our attention.

Abstraction is necessary to all knowledge. As soon as we advance at all beyond the knowledge of concretes—as soon even as we begin to compare one thing with another, and note their resemblances and differences—so soon we commence the process of abstraction and generalization. This mental act is not only the foundation of all conscious classification, but it is itself the infancy of consciousness. The earliest perception of resemblance in two objects which, next to the perception of difference, is the lowest term to which consciousness can be reduced, and which probably appeared contemporaneously with organized matter, was the result of incipient abstraction. The likeness of two things not identical, but resembling each other in many respects, would be perceived by any being possessed of the least consciousness. As the differences increase and the resemblances decrease in number, it is only by a thinking away from (abstracting) the differences and confining the attention to the resemblances, that classification commences.

One of the greatest difficulties in dealing with the early growth of consciousness is the lack of terms applicable to it. Man commences to philosophize only when he is far advanced in culture, and the terms he then uses are ill fitted to express the mental acts of men far below him in intelligence, and in a still greater degree of those lowest orders of animals in whom consciousness first appears. However ill they may express our meaning, we are confined to the words we have, and they must be accepted as indicating but in a slight degree the mental process going on in the early organisms. When we speak of the abstraction necessary to the perception of resemblance, it is of course to be understood that the process is but slightly analogous to the classification of the scientist; still, fundamentally it is the same. For long ages before man appeared upon the earth this unthinking classification was going on. A brain was gradually being developed which had impressed upon it the experiences of its myriad ancestors, and which furnished to the primitive man an instrument of thought enabling him to adapt himself to surrounding conditions with far more success than his less favored compeers. The æons during which man struggled with the forces of nature, all the while gaining slight increments of experience and knowledge of nature's laws which he transmitted to his descendants, were necessary to the production of the Greek philosopher who, from his highly specialized mind, could evolve a theory of the universe. Ignorant of the vast ancestry of human experience, it is no wonder that men should have been ready to accept any but the true explanation of our belief in the laws of nature, and should have been unable to discern any relationship between those laws which to them appeared necessary and immutable and those newly discovered laws or sequences which they believed might be easily set aside.

Viewed in the light of evolution, a law of nature is merely the most generalized expression for a particular occurrence of phenomena. Take, for instance, the law of the conservation of energy: observation, long continued, shows that with whatsoever objects we deal, and however we may apparently destroy the energy contained in them, yet closer observation, with more accurate instruments, will discern that the energy previously visible has only disappeared to reappear in another form. Finding the same result in every case to which we are able to apply our tests, and discovering no exception to the rule, we abstract the particular objects we have been considering, and, confining our attention to the persistence of energy which each displays, group this class of phenomena into one category and express the likeness by the law that energy endures.

Each deduction from a law is a separate verification of its truth, and as these verifications increase in number the probability of finding an exception decreases. Hence, the law soon assumes a form of necessity as different as possible from its original character. Add to this that many of the laws of nature have only to be expressed to be admitted —laws whose concretes were objects of observation to our earliest ancestors away back in the youth of life upon our globe, and are, to us at least, intuitive—and we see how natural the attribution of necessity to them appears. Besides this, the word law conveys a meaning entirely outside its scientific acceptation. As popularly used it expresses the command of a ruler; and this civil or theological meaning, as applied to the laws of nature, is continually being brought to scientific discussions, much to the detriment of their clearness. Mathematics alone among the sciences has been able to keep clear of these dangerous alliances, and we there still see the word used in its properly scientific application as an order of sequence merely. Although mathematical law is not coextensive with physical law, it is this meaning which we should endeavor to preserve. The word is an unfortunate one at best, and some philosophers and scientists have advocated its disuse and the substitution of some more accurate term; but it is too deeply rooted in scientific language for that, and we can only enter a protest against its use in scientific discussions in other than a scientific sense. We have only to consider the scientific genesis of the term to obtain a rule for its application. Considered merely as the generalized expression of the result of observation, we clearly perceive that, however long these observations may have continued, they carry with them no necessity except in so far as relates to our own organism. It is just here that the idea of necessity asserts its power. Take the most fundamental law of mechanics, or even (for the supposed necessity in each case arises in the same way) one of the primary axioms of mathematics, and, by an analysis of the genesis of these conceptions, we shall, with the aid of the light that the theory of evolution sheds into those obscure recesses of the mind where consciousness is coming into

being, be enabled to perceive there the process of the growth of this mental necessity in direct correspondence with the evolution of the organism. Through untold ages have the ancestors of man beheld numberless objects break into parts, no one of which was ever as large as the original whole. Through vast geological ages have these facts been impressed upon an evolving mind which, as it never perceived the contrary, had not the data upon which even to imagine it. With this immense induction behind him no wonder, man, when he was able to speculate, asserted the necessary truth of the axiom that "the whole is greater than any of its parts." A necessity for a particular order in nature we know nothing of; that conception arises from the growth of the organism in correspondence with nature as it is.

The old metaphysical conception of types has perhaps had as much influence on scientific controversy as any abstract term. Alike with species, useful when regarded purely as an abstraction from concretes and as an hypothetical form about which to group different individuals, when regarded as a reality it may prove, even in the hands of an able scientist, an *ignis fatuus*, luring him from the solid ground of scientific knowledge into the quagmires of metaphysical speculation. Like all abstractions, when sufficiently limited in their application, they may lead to useful results, and may suggest resemblances that might otherwise escape the observer. Thus to the conception of types was Goethe indebted for the valuable suggestion he gave to biology. Although these realistic conceptions of abstraction have sometimes brought forth valuable scientific hypotheses, yet their effect commonly has been the reverse. Like the doctrine of final causes, which is popularly supposed to have suggested to Harvey the circulation of the blood, by opening the question as to the use of the valves in the veins, so the doctrine of the existence of types has sometimes been productive of good results; but, as the doctrine of final causes, whatever may be its theological truth, is utterly extra-scientific, and has consequently been a steady opponent of any advance beyond present knowledge, so the theory of types has proved one of the strongest enemies to the acceptance of the theory of evolution. It was his metaphysical belief in this conception that was avowedly the basis of Agassiz's opposition to evolution. Types and species were to him real existences, to which phenomenal existence corresponded. There existed in the universe, for instance, an archetypal form on which vertebrates were modeled. Genera and species corresponded with these types in a greater or less degree, and the assumption that varieties were incipient species which, by successive modifications, could grow into "good species," was, in his view, the introduction of complications into biology sufficient to destroy all classification. Looked at from this standpoint, his vast biological knowledge only served to furnish him with stronger weapons in defense of his position. It may well be doubted whether any proof, however strong, would have been suffi-

cient to have changed his opinion ; for metaphysical conceptions, like spiritual substances, yield to no carnal weapons.

Herein consists the great danger in the introduction of abstractions into scientific discussions. Let them once be assumed to have an existence outside the concretes from which they are formed—and the tendency with many is to consider them in this light—and no argument, based upon the observation of phenomena, is sufficient to overthrow them. It can not be too strongly impressed upon the minds of all that science has nothing to do with such conceptions. As science consists in the observation of phenomena and the deduction of the laws of their orderly occurrence, and as scientific hypothesis consists in the prediction of the order of the future occurrence of phenomena and the linking together of diverse phenomena under an assumed order, we see that there is no place where these realistic conceptions can enter. Their sphere, if anywhere, is in metaphysics and theology. Scientists should exercise the utmost care not to misapprehend their own terms, and should then compel acquiescence in the meaning they give to them. Looseness in the use of words is one cause of the indefiniteness that pervades the controversy between the scientists and the theologians.

Force, cause, matter, and science itself are abstract terms, and when analyzed into their concretes will assume a meaning very different from that often given them. All that we scientifically know of force is, that it connotes the presence of motion (i. e., things moving) under different conditions. These we separate into actual and potential motion, and the cause of the motion into actual and potential force or energy. Here the necessity of the use of these abstract terms is at once apparent, as we can scarcely make an assertion without employing them. Cause, as in the above-mentioned case of law, is simply the preceding conditions of any phenomenon, and in the absence of which, as far as we know, it can not occur. Likewise matter, the most "real" of all abstractions, is, scientifically speaking, merely the symbol of a congeries of the phenomena of extension ; and Professor Tyndall was speaking entirely within scientific bounds when he said he discerned in it the promise and potency of all forms of life. This did not in the least prejudice the materialistic-idealistic controversy as to its ultimate constitution. In his case he had repeatedly distinctly avowed his non-acceptance of metaphysical materialism, and in a few concise sentences had adduced a stronger argument against that belief than can easily be found in the literature of the subject. The same may be said about the use of the term "vitality" by Professor Huxley and its relegation by him to the limbo of other defunct "itys." This, which has never ceased to be a red flag in the face of bellicose clergymen, was entirely within his province, and was merely a fine example of the exactness of definition of modern scientific nominalism. This misconception of the scientific use of abstraction appears in almost all the current criti-

cisms of the utterances of scientific men from a religious standpoint. The fundamental difference between the scientific and religious conception of nature consists almost wholly in the manner of regarding abstract terms. Causes—efficient and final—mind, life, and the whole category of vast abstract entities, are to the religionist the most real of all existences; to the scientist they are merely generalized expressions, binding together a large class of phenomena.

The term science does not, like the name of a religious sect, denote the belief in a set dogmatic formula, nor the acceptance of a certain class of ideas. There is no orthodoxy nor heterodoxy in science. On the contrary, the term science connotes the knowledge of the occurrence of certain phenomena in a certain definite order; and the term scientist denotes one who is versed in these facts, and who, from his knowledge of the past, is capable of making more or less probable guesses (hypotheses) as to the occurrence of these phenomena in the future, or in unexplored portions of the past. The attribution of more than this to the term science is not warranted. To say that true science teaches one thing and false science another is wrong. Science teaches nothing; it is itself knowledge rendered more exact. Vagueness of language and a looseness in the use of words lie at the root of many a difficulty. When we think of the numerous disputes that grow out of the misuse of words even on simple topics, and the difficulty there is in confining one's self to their pure signification, we can not wonder at this. It is a common defect in early education that pupils are not taught to attach sensible experiences to the words they repeat. Words are used with but an indefinite apprehension of the objects they are symbols of, and indistinct conception of the thought of others engenders indistinct thought in ourselves. It by no means suffices to establish the etymological meaning of words, for they are not, for the most part, scientifically constructed terms with precise significations, but are the result of the constant adaptation of old words to new uses, and are consequently often much distorted from their original meaning. Plato affords us an excellent model of the way to get at the meaning of terms. Take any of the Socratic dialogues and notice the trenchant manner in which the husks are severed from the true meaning of the words, and we see just what we must do with scientific terms if we would preserve their clearness. Should the logical teaching of our schools and colleges enforce this dialectical method as applied to scientific abstractions, we should see fewer attacks upon scientific men by those who utterly misapprehend their position.

It must be ever borne in mind that the scientist, as a scientist, has nothing to do with the metaphysical or theological implications of the words he uses. He employs them, as we have endeavored to point out, simply and purely to designate the occurrence of phenomena in a certain order which, could we sufficiently magnify our powers of observation, would be presented to our sensation in unequivocal terms.

When the scientist transcends these limits, and then only, he is going beyond the bounds of science. The temptation to stroll about, regardless of limits, is often great, and the scientist, like most of his kindred, frequently indulges in these aberrations. When thus found, he is entitled to no consideration on account of any sovereignty he may claim to exercise in his usual habitat, and, if overthrown, may be drawn and quartered at the will of his victorious enemy without a remonstrance being uttered by his fellow scientists. He thus occupies a dual position: in one the knowledge he possesses gives to his assertions a certain authority and to his hypotheses a certain probability of which they are devoid in the other. The discussion and consideration of religious questions by scientific men is a common illustration of this; but the attempt to throw the weight of scientific authority on to one side or the other of any question regarding supra-sensible objects should be steadily frowned down. The acceptance of a thorough nominalism in science and as thorough a realism in religion is by no means incompatible. Faraday is reported to have replied, to an inquiry as to how he, with his well-known scientific rigor of thought, could hold certain religious opinions, that he did not subject those opinions to scientific tests, as he well knew they could not survive them. Nevertheless, he held them as firmly as though convinced of their scientific soundness. The knowledge of the disintegration of the body after death may coexist with a strong religious faith in its resurrection. A large proportion of scientific men hold religious beliefs for which they have, and care for, no scientific justification. The logical soundness of such a position we will not here discuss. All that we care to do now is to assert most strongly that in science abstractions have no "real" existence, and that, when the scientist says that the explanation of certain powers of animal life by the term "vitality" is no explanation, or that consciousness is dependent upon organization, or uses any of the thousand and one kindred abstractions in a scientific sense, it is sheer meddling to interfere. Were the duty of keeping metaphysics at home inculcated with half the ardor that is used in urging science not to stray, we should hear much less of the conflict between religion and science. As it is, the modern Quixotes see in every scientific definition an imaginary giant, which it is their duty and privilege to destroy. Would they observe a little more closely, they would discover the harmless mechanism of the structure, and would reserve their energies for attacks upon more vulnerable enemies.

THE AGE OF ICE.*

By H. B. NORTON.

ANCIENT moraines, striations denoting the action of vanished glaciers, the lost rocks, clay-beds evidently of glacial origin—all these are evidences testifying that at some period not very remote, as we count geological periods, the whole northern hemisphere down to the southern limit of 40° was submerged and covered with vast glaciers and ice-floes. There is not a living scientist of any eminence who questions the truth of this assertion.

When we come to study the cause of these phenomena, we find many perplexing and contradictory theories in the field. A favorite one is that of vertical elevation. But it seems impossible to admit that the circle inclosed within the parallel of 40°—some 7,000 miles in diameter—could have been elevated to such a height as to produce this remarkable result. This would be a supposition hard to reconcile with the present proportion of land and water on the surface of the globe and with the phenomena of terrestrial contraction and gravitation. Moreover, it seems evident that an extensive submergence was one of the features of the glacial age. The frozen archipelago called Greenland is a fair picture of what northern America and Europe must have been at that time ; and, of course, this precludes the idea of elevation.

If it were not true that submergence and a great lowering of temperature occurred simultaneously, we might imagine that a sort of undulation in the earth's crust, alternately raising and lowering each portion of it, could have caused this result. However, there is no evidence that such an undulatory motion has ever occurred, and we can not conceive of any force likely to produce it.

For the past fifty years, the relation of the inclination of the earth's axis to the plane of the ecliptic and its varying angle with the line of the apsides, has been the subject of careful study, from the impression that herein was a key to the mystery. Astronomical and geological works abound with hints and suggestions of this sort, but I have never yet seen any satisfactory analysis of the question. St. Pierre, Adhemar, and others have presented theories which seem strangely illogical in many of their conclusions. I have been striving to analyze the question, and will present a few of my conclusions.

The orbit of the earth is an ellipse, of which the sun occupies one of the foci. The major axis, or line of the apsides, is the longest diameter of the ellipse, passing through its two foci and through the points of perihelion and aphelion. This line is not fixed with respect

* Abstract of a lecture delivered before the Kansas Academy of Science.

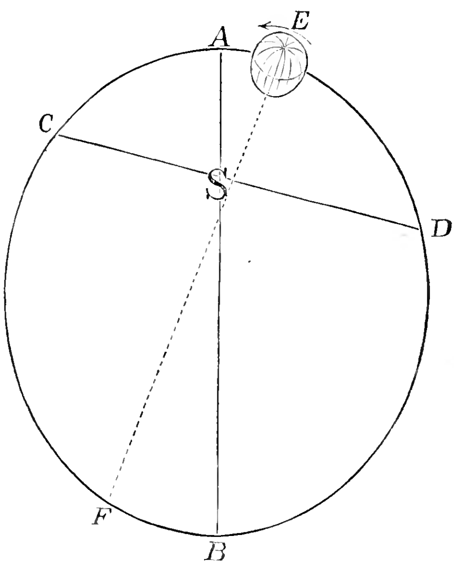
to the other bodies in space. Owing to the attractive force of the other planets, it is slowly revolving in the same direction that the earth moves in its orbit. The rate of revolution of this line of the apsides or major axis is a little over 11·6″ a year.

We ordinarily speak of the earth's axis as being always parallel to itself. It is, in fact, however, subject to a very slow gyratory motion, caused by the attraction of the sun upon the *meniscus*, or ring of matter bulging at the equator, which motion is retrograde, or in an opposite direction to the revolution of the earth. This retrograde motion causes the phenomenon known as the precession of the equinoxes. Its rate is about 50·3″ a year.

It will thus appear that a vast period of time will elapse before the earth's axis will occupy the same position with respect to the line of the apsides that it occupies to-day. This period is sometimes called the Great Year. Its length may be ascertained by reducing three hundred and sixty degrees to seconds, and dividing this quotient by the annual amount of the two motions described above :

$$1{,}296{,}000'' \div (50{\cdot}3'' + 11{\cdot}6'') = \frac{1296000''}{61{\cdot}9''} = 20{,}937.$$

The Great Year is thus seen to be about 21,000 years in length.



A, Perihelion ; *B*, Aphelion ; *E*, Winter Solstice ; *F*, Summer Solstice ; *D*, Autumnal Equinox ; *C*, Vernal Equinox.

I have here drawn a diagram illustrating the present position of the earth's orbit with respect to the line of the apsides, purposely exaggerating the eccentricity of the ellipse in order to better present it to the eye of the observer. In the diagram, A B is the line of the

apsides ; C and D are, respectively, the vernal and autumnal equinoxes ; E F is the section of a plane passing through the poles of the earth at right angles with the plane of its orbit. It is evident that this plane will coincide with the line of the apsides once every 10,500 years ; E is the winter solstice ; F the summer solstice ; C is the vernal equinox. While the earth is passing through B to D the north pole is inclined *toward* the sun. This period is the summer of the northern hemisphere.

D is the autumnal equinox. While the earth is passing from D through A to C, the north pole is inclined *from* the sun. This period is the winter of the northern hemisphere. In the southern hemisphere these seasons are reversed.

By consulting the diagram it will appear that the arc C B D is greater than the arc D A C. Therefore, the summer of the northern hemisphere is now longer than its winter. On the contrary, the winter of the southern hemisphere is now longer than its summer. At present, this difference is about eight days. It has been greater, but is gradually diminishing.

The southern hemisphere has at present a winter of 187 days, and a summer of 179 days. We may justly infer that during this winter more snow and ice accumulated at the south pole than the heat of the shorter summer is able to melt. The amount of this increase is very slight in a single year, but it accumulates a large aggregate in the course of ages.

This accumulation of ice at the south pole is continually increased and thickened by the deposition of moisture from the atmosphere. Every wind from warmer regions that passes over it adds to its mass.

The "Antarctic Continent" is an ice-cap, nearly circular in form, and about 3,000 miles in diameter, unexplored and uninhabitable. We can not easily ascertain its thickness. The arctic ice-cap is much smaller, and is honeycombed by the Kuro Siwa, or Japan Current, and the Gulf Stream. Nevertheless, the Greenland Archipelago seems covered with glaciers often several thousand feet in depth. If we could assign to the Antarctic ice-cap a thickness of 15,000 feet, we should have a mass of ice large enough to displace the earth's center of gravity nearly a mile to the southward of its center. A gradual displacement of this sort, caused by the slow accumulation of ice, would produce an imperceptible drainage of the oceans from the north to the south, and the gradual emergence of northern and submergence of southern continents.

If we examine the globe, we seem to discover an actual result of this sort. The greatest mass of the ocean is gathered about the south pole. The northern hemisphere includes about five sixths of the land-surface of the globe.

Moreover, geologists affirm that this inequality is increasing ; they assert that the northern continents are slowly rising, and that the isl-

ands of the south Pacific are sinking. It is more probable that the water is slowly draining away from the northern hemisphere and accumulating in the southern. If our hypothesis be true, this process will continue for some thousand of years to come; until, through the submergence of southern lands and the extension of the Antarctic ice-cap, the condition of the southern hemisphere will approximate to that of the northern continents during their glacial age. Indeed, if the present position of the earth's axis with respect to the line of the apsides were invariable, we might expect to see a final complete submergence and refrigeration of the southern hemisphere.

But this position is not invariable. As I remarked above, it is slowly changing, making a complete revolution in 21,000 years. Refer to the diagram, and you will see that when F coincides with B, the winter of the southern hemisphere is longest; when F coincides with C, winter and summer in each hemisphere are of equal length; when F coincides with A, the summer of the southern hemisphere is longer than its winter. The earth occupies successively all these situations during its great cycle of 21,000 years. Each hemisphere passes through alternate periods of a preponderance of summer or winter; each period being 10,500 years.

There is one more factor in this problem which must be considered, and that is the periodical variation in the ellipticity of the earth's orbit. Sometimes the line of the apsides is longer than at other times. This variation occupies regular but vast periods of time. It is evident that when the variation is greatest, the accumulation of ice at the winter pole must be most rapid.

The 10,500 years during which the pole is refrigerated and deluged, may be called its great winter; the other half of the cycle, its great summer.

Unless astronomical calculations fail, the last great summer of the northern hemisphere commenced some 6,500 years ago. When it began, northern America, Europe, and Asia were frozen and deluged. The Arctic Ocean extended to a line south of the present bed of the Great Lakes. The Alps and the Alta were also southern boundaries of this ocean. Europe was the home of a swarthy, dwarfish race, who hunted the aurochs and great hairy mastodon at the foot of the glaciers that then half overflowed the continent.

But the intenser suns of many ages have done their work. The glaciers have melted, dwindled, retreated to the high Alpine valleys, and to the high northern latitudes. The swarthy troglodytes and lake-dwellers have followed them. Under the name of Esquimaux, Lapps, and Finns, a feeble remnant of these preadamite people still lingers within the Arctic Circle; but their doom as a living race seems near and sure. The Aryans have come marching across the Eastern steppes, for the building of society, civilization, human history.

In the outset of this argument, I assumed an Arctic ice-cap 15,000

feet in thickness, and a displacement of the earth's center of gravity one mile toward the north at the height of the glacial age. In fact, it is not necessary to assume any such amount of displacement. If the earth's center of gravity coincided with its center, so as to equalize the amount of water in the northern and southern hemispheres, Itasca Lake would not be more than 600 feet above sea-level. Now push the center of gravity 2,000 feet toward the north, and the Arctic Ocean would be so much deeper over the pole, and the water would be about 1,000 feet deeper at the latitude of 45°. To accomplish this result, we must calculate that the space within the Arctic Circle was covered by an ice-cap averaging perhaps 8,000 feet in thickness—an entirely supposable case. Such an amount of displacement would flood all the low lands of North America down to the line of 40°, and fully satisfy all the conditions of the problem.

It thus seems probable that there have been many glacial periods in each hemisphere, and that the ocean, like a mighty pendulum, vibrates from pole to pole through vast but regular periods. It is not necessary to suppose a cataclysm at the end of each period, as some of the earlier writers did; but rather, an insensible drainage of waters, which so gradually submerges the lands and pushes the human race before it, as hardly to be perceptible in the course of generations; ever uncovering new continents, and opening up fresh fields and pastures new to human industry, when the old are exhausted.

The southern hemisphere is now undergoing the slow refrigeration of its long winter. This began about 6,500 years ago; it will end about the year 4,870. It has passed its middle, but not its culmination, even as the greatest average cold of our ordinary winter is nearer the vernal equinox than the winter solstice. It is probable that, 2,000 years from now, the southern continents will be still more deeply deluged; the Antarctic ice-cap will have extended several hundred miles to the northward, and the glaciers which have already appeared among the Andes will have covered the plateaus of Patagonia and Chili. Nevertheless, we need not expect that mankind will then witness the utmost possible degree of refrigeration, because the ellipticity of the earth's orbit is now less than it has been at certain periods in the past, and will be again in the remote future.

I feel that, in this discourse, I have ventured upon doubtful and perilous ground. Nevertheless, however illogical and imperfect my conclusions may have been, I feel certain that herein is the key to the mystery. I leave the question, trusting that abler minds may be directed to its consideration and solution.

SKETCH OF PROFESSOR FRANKLAND.

AMONG the eminent men of England whose names are closely associated with the contemporary progress of chemical science that of Dr. Frankland has a distinguished place. Having a genius for the theoretical and speculative side of his favorite subject, together with a thorough and comprehensive discipline in experimental operations, he has devoted himself with equal zeal and success to pure chemistry, to its physical relations, and to its large applications to public and sanitary questions which depend for their elucidation upon chemical knowledge. Eminent also as a teacher and an organizer of research, and occupying many positions of responsibility, he has exerted a powerful influence in drawing students to this branch of study, and in awakening their enthusiasm in its pursuit.

EDWARD FRANKLAND, D. C. L., Ph. D., F. R. S., President of the Institute of Chemistry of Great Britain and Ireland and Professor of Chemistry in the Royal School of Mines, London, was born at Churchtown, near Lancaster, February 18, 1825. He was educated at the Lancaster Grammar School, and studied chemistry at the Museum of Practical Geology in London, under Lyon Playfair; and he was also a student at the Universities of Marburg and Giessen, where he worked in the laboratories of Bunsen and Liebig. At Marburg in 1849 he received the degree of Ph. D. when he presented a dissertation upon his discovery of a method for isolating the radical of alcohol and ether. In 1851 he was appointed Professor of Chemistry in Owens College, Manchester, and he also became Professor in St. Bartholomew's Hospital, London, in 1857. In 1863 he was appointed Professor of Chemistry at the Royal Institution of Great Britain, and in 1865 he succeeded Dr. Hofmann at the Royal College of Chemistry (School of Mines), then in Oxford Street, but since removed to South Kensington. He was elected Fellow of the Royal Society in 1853, and in 1870 he received the honorary degree of D. C. L. of Oxford.

In 1868 Dr. Frankland was appointed, in conjunction with Sir W. Denison, K. C. B., and J. Chalmers Norton, Esq., one of her Majesty's commissioners for inquiring into the pollution of rivers. The results of these inquiries were embodied in six reports presented to Parliament, five of them dealing with the pollution of rivers by the drainage of towns and manufactures, and the sixth with the domestic water-supply of Great Britain.

In 1871 he was elected President of the Chemical Society, and he became the first President of the Institute of Chemistry in 1877. All the chemical articles in the Arts and Sciences division of the English Cyclopædia were written by Dr. Frankland, or under his immediate supervision. The "Philosophical Transactions" for 1852 contain a long

memoir by him, entitled "On a New Series of Organic Bodies containing Metals." This important communication concludes with some theoretical considerations in which the analogy of the organo-metallic bodies with cacodyl is pointed out, and in which that character of elements which has since been termed "atomicity" was first described. In 1857 a royal medal was awarded him by the Royal Society for his "Researches on Organic Radicals and Organo-Metallic Bodies."

In the "Journal of the Chemical Society" (1866) Dr. Frankland published his "System of Notation" by which the formulæ of bodies are made to represent the mode in which the atoms composing them are arranged in accordance with their atomicity. This system has proved of great service in elucidating the causes of isomerism in organic compounds. His "Lecture Notes for Chemical Students" was published in 1866—third edition, two volumes, in 1876. His celebrated memoir, "On the Source of Muscular Power," was printed in the "Philosophical Magazine" in 1866. He gave a course of six lectures before the Royal College of Chemistry, entitled "How to teach Chemistry," which was summarized for publication by George Chaloner. Dr. Frankland is the author of numerous papers published from time to time in scientific periodicals, among which may be mentioned, "Observations Economical and Sanitary on the Employment of Chemical Light for Artificial Illumination"; "Contributions to the Knowledge of the Manufacture of Gas"; "Researches on the Influence of Atmospheric Pressure on the Light of Gas, Candle, and other Flames"; on "Winter Sanitariums in the Alps and Elsewhere"; on the "Purification of Town Drainage and other Polluted Liquids"; and on "The Composition and Qualities of Water used for Drinking and other Purposes." He is also the author, conjointly with Mr. J. Norman Lockyer, of "Researches connected with the Atmosphere of the Sun."

In 1857 Professor Frankland published "Experimental Researches in Pure, Applied, and Physical Chemistry." It forms a volume of over a thousand pages, which was issued by John Van Voorst, of London, and embraces the main researches of his scientific career. It has a very full table of contents, an exhaustive index, and a large number of illustrations of apparatus used in research; graphic tables are also included, representing to the eye the results of extensive series of experimental investigations. The volume embraces the records of experimental work in pure, applied, and physical chemistry, extending over thirty years, and scattered through many English and foreign transactions and journals. They are grouped into subjects and arranged chronologically, with a new introduction to each chapter, showing its scope, the relations of the several papers to each other, and their bearing on subsequent inquiries. A uniform system of nomenclature and notation is adopted (except in the section on applied chemistry), the principles of which are explained in an opening memoir. The work is thus unified, and, being carefully edited and revised so as to

give it the highest accuracy at the present time, it forms altogether a kind of comprehensive report upon the present state of the science in many of its most interesting and important aspects.

It may be remarked that the chemical inquiries detailed in this work took at first an analytical direction, with the object of isolating and identifying the proximate constituents or radicals of which organic compounds are constructed. Then they became synthetical, and were directed to the artificial building up or evolution of organic compounds. Some of these were already known as products of animal and vegetable life; while others, of at least equal complexity, were new additions to the category of organic bodies. In both cases their synthetical construction brought to light trustworthy evidence of their molecular architecture.

Dr. Frankland's investigations in applied chemistry, and especially those upon the purification of the sewage of towns, and the treatment of foul liquids from manufactories, and which were undertaken at the instigation of the Government, are most valuable. The results of the investigations on gas and water will be of service to engineers, manufacturers, agriculturists, local boards of health, and others interested either in the supply of gas and water to towns, the removal and utilization of foul drainage, or the health of populous places; for, in pursuing his inquiries Dr. Frankland did not confine himself to indispensable experiments and observations merely, but endeavored to discover the general principles underlying the various processes.

Dr. Frankland has been awarded honors from a large number of scientific bodies in England and on the Continent. He is Corresponding Member of the French Academy of Sciences; Foreign Member of the Royal Academy of Sciences in Bavaria; and of the Academies of Sciences of Berlin, St. Petersburg, and Bohemia. He is also Honorary Member of the Societies of Natural Sciences of Switzerland and of Göttingen; of the Literary and Philosophical Society of Manchester; of the Chemical Societies of Germany, America, and Lehigh University, United States; of the Sanitarian Society of Dresden, and of the Pharmaceutical Society of Great Britain.

CORRESPONDENCE.

SERPENT-CHARM.

Messrs. Editors.

IT would seem that, in his paper on "Serpent-Charm" in the September number of the "Monthly," Dr. Oswald overlooks a factor which is of too great importance to be wholly disregarded. That this is the case may be shown by an incident coming under my own observation, and two or three references.

While passing through a poultry-yard in September, 1878, I noticed a turkey-hen with neck stretched to the utmost, eyes fixed, and wings slightly raised, gazing most intently at some object on the ground three or four feet from where it stood. Watching it for some moments, I found that the turkey moved slowly around the attracting object in a circle, without withdrawing its gaze for a moment. After it had made a full circle, I approached to learn the cause of its extraordinary behavior, and found that the attracting object was a small striped snake partially concealed by some low weeds; and not until I touched it did the turkey notice my presence, though ordinarily it would not permit me to approach within two or three yards. Even when driven away, the turkey persisted in returning to fix its eyes on the little snake anew, when it would immediately cease to regard me in the least; and only when driven to the opposite corner of the large yard did it seem to forget its attraction to the spot.

Several other fowls, including chickens, other turkey-hens, and an old turkey-cock, were then driven singly in the direction of the snake, and each was found to be more or less affected on catching a glimpse of it, though most of them were satisfied to retire after viewing it attentively from several points. Nearly all, however, walked slowly entirely around it, and all extended their heads toward it in the most ludicrous manner. Finally, a flock of geese was driven by. On seeing the reptile they tipped their heads to one side and watched it attentively while they turned aside to pass around it, and, after all had passed in safety, expressed their relief by loud outcries.

Satisfied that the condition of the fowls, on seeing the reptile, was a purely subjective one, I approached to kill it, when, to my astonishment, I found it already dead, its head being crushed out of all semblance to its original shape, and covered with dust. I subsequently learned that it had been killed by a member of the family. I have since had two or three opportunities to verify the fact that fowls may be thrown into a condition in which volition seems to be partially or completely paralyzed by the sight of a perfectly harmless snake, and it seems to be almost wholly immaterial whether the reptile is alive or dead, provided it retains its natural form and position.

Monkeys are similarly affected by the sight of a snake, though they are not so completely paralyzed as fowls often are. Brehm relates that his monkeys were filled with dread on seeing some serpents, yet they "could not desist from occasionally satiating their horror in a most human fashion by lifting the lid of the box in which the snakes were kept"; and Darwin observed the same thing in the monkeys in the London Zoölogical Gardens, among which he introduced a stuffed snake: "After a time all the monkeys collected round it in a large circle, and, staring intently, presented a most ludicrous appearance. They became extremely nervous, so that when a wooden ball, with which they were familiar as a plaything, was accidentally moved in the straw, under which it was partly hidden, they all instantly started away. . . . I then placed a live snake in a paper bag, with the mouth loosely closed, in one of the larger compartments. One of the monkeys immediately approached, cautiously opened the bag a little, peeped in, and instantly dashed away. Then I witnessed what Brehm has described, for monkey after monkey, with head raised high and turned on one side, could not resist taking a momentary peep into the upright bag, at the dreadful object lying quietly at the bottom." ("Descent of Man," Appletons, 1877, pp. 71, 72.) Similar excitement was exhibited by the monkeys in the Philadelphia Zoölogical Gardens, when a dead snake was placed in their cage, as recorded by Mr. A. E. Brown in "The American Naturalist," and quoted in "The Popular Science Monthly" for July, 1878 (Vol. XIII., p. 379).

The condition into which these monkeys—and more particularly the fowls mentioned above—are thrown on seeing the frightful object is so nearly identical in its causes and its manifestations to hypnotism or katalepsy as to indicate a very intimate relationship therewith; and to this condition many birds and small animals are extremely subject. "Preyer has succeeded in rendering kataplectic various species of toads, newts, frogs, ducks, poultry, peafowl, par-

tridges, sparrows, mice, Guinea-pigs, rabbits, etc." ("Popular Science Monthly Supplement," xviii., p. 574); and he considers that fear is the chief cause of the inhibition of spontaneity. In view of these premises it seems not improbable that the same species might pass into a similar subjective condition on being suddenly brought in view of serpents, of which all of these animals stand in great dread. Indeed, this is in substance the explanation of serpent-charm given by Dr. Preyer himself. Granting this, it is easy to see that the ophidians, whose intelligence is, according to Darwin (ib., 352), "greater than might have been anticipated," would be likely to learn to take advantage of it. As soon as this took place, serpent-charm would be practically established as a factor in the animal economy, though perhaps a very unimportant one; and in corroboration we have the evidence of Preyer and several other naturalists, who accept the "fascination of birds by snakes" as a scientific fact; while, as Dr. Oswald admits, we have the testimony of eminent ophiologists that snakes are unable to capture birds unless aided in some manner. Of course it is not yet established by competent observers that small birds and animals do actually pass into a subjective condition on seeing a snake (and the evidence adduced by Dr. Oswald is of a negative character), but it seems more probable that this is so than that the few skilled and the many unskilled observers should have erred so egregiously; and it is certainly much more probable than that the popular notions regarding serpent-charm should have originated in the aimless struggles of birds or small animals wounded to the death by the fangs of a venomous serpent.

Very truly yours,

W. J. McGee.

Farley, Iowa, *September* 1, 1879.

EDITOR'S TABLE.

THE SCIENTIFIC ASSOCIATIONS.

THE scientists had a profitable and pleasant time at Saratoga. The twenty-eighth annual meeting of the American Association for the Advancement of Science, which met there this year, was well attended and successful in every respect. A larger number than usual of the old and eminent members of the body were present, and that the gathering represented a goodly proportion of the scientific working power of the country is shown by the fact that about one hundred and fifty papers were contributed, in different fields of inquiry, many of which were of marked merit. There are two or three respects in which the proceedings were noteworthy, and to which we desire to call attention.

The American Association was formed upon the model of the British Association, which had been in operation for some years, and incorporated its main features. They embrace common objects, and have both undergone a development that has accompanied the progress and widening of scientific thought. Their annual sessions occur so nearly together that the contributions from both sources come upon us at the same time; and, regarding them as substantially one organization, we select their papers for printing by the rule of convenience. The able inaugural address of President Allman at the Sheffield meeting appears in our present number, and we shall publish a revised edition, with notes, of the equally able address of Professor Marsh at Saratoga in our next issue. In his address before the Physiological Section of the British Association, over which he presided, Dr. P. H. Pye-Smith stated the leading objects of the organization, as follows:

"The Association to which we belong seeks to advance natural science, that is, accurate knowledge of the material world, by the following means:

"1. By bringing together men who are engaged in the various fields of science indicated by our several sections, by promoting friendship between them, by giving opportunity for discussion on points of difference, by encouraging obscure but genuine laborers with the applause of the leaders whom they

have learned to venerate, and by fostering that feeling of respect for other branches of science, that knowledge of and interest in their progress, which chiefly mark the liberality of scientific study.

"2. The Association provides funds which, though small in amount, are great in worth, from the mode of their distribution; and serve in a limited degree as an encouragement, though not an endowment, of research.

"The third most important aim of our Association is, 'to obtain a more general attention to the objects and methods of science, and the removal of any disadvantages of a public kind which impede its progress.' It is for this reason that the Association travels from one to another of the great centers of population and intellectual activity of the kingdom, local scientific societies and local museums are generated and regenerated in its path, local industries are for a time raised to a higher level than that of money-getting, and every artisan may learn how his own craft depends upon knowledge of the facts of nature, and how he forms part of the great system of applied science which is subduing the earth and all its powers to the use of man. We wish to make science popular, not by deceiving idlers into the belief that any thorough knowledge can be easy, but by exciting interest in its objects, and appreciation of its methods. In the popular evening lectures you will hear those who are best qualified to speak upon their several subjects, not preaching with the dry austerity of a pedant, but bringing their own enthusiasm to kindle a contagious fire in those who hear them."

Of course the prime object of these bodies is the promotion of science by means of original investigation and the development of new views; but it is not for a moment to be overlooked that these objects can only be efficiently secured by appropriate means. Experimental investigations and systematic observations on the varied phenomena that solicit inquiry are only to be made by outlays of time, labor, and money. The scattered students of original science work generally alone, and with such facilities as they may be able to command; but it is one legitimate object of combination to enlarge the opportunities of research, and give help and encouragement to isolated inquirers. Occasions, moreover, are constantly arising in which investigations become so comprehensive and methodical that they can not be carried on by individual resources, and outside aid is indispensable. It has been an important part of the policy of the British Association to furnish means for carrying on various investigations of this kind, the results of which are reported at its annual sessions; and, from the outset, one of its objects has been to raise money for such purposes. Funds thus appropriated, as Dr. Pye-Smith remarked, serve as an encouragement to research without becoming a formal endowment. The Association marks out or approves a course of inquiry, and then gives substantial assistance in carrying it on to parties especially qualified for the work; and thus the utmost equivalent for the money expended is certain to be secured. This admirable feature of the British Association ought to be initiated and developed by our own society, and to this end we venture to think there should be more systematic effort to secure voluntary contributions. The American Association has not abounded in worldly wisdom to anything like the degree that its nationality would justify. Absorption in pure scientific work seems to have been unfavorable to the practical business element. This has limited the usefulness and efficiency of the organization, for money is as much the sinew of science as of war. It is to be hoped that in future increasing attention will be given to this sub-

ject; and that a special department of the society will be constituted a committee of ways and means to raise contributions and devise expedients for enlarging its usefulness.

But, though the American Association has not hitherto developed much financial skill, it is gratifying to note that it is making increasing efforts to excite public interest in its objects. Undoubtedly, the great impediment to scientific progress is popular ignorance, indifference, and lack of sympathy with the aims to which men of science are devoted. The energy, the culture, and the influence of the active classes of society are not sufficiently enlisted in behalf of this work. It is in the line of its legitimate duty for the Association to take advantage of its opportunities, as it yearly passes from city to city, to present the claims of science to the public in such a manner as to arouse enthusiasm in their behalf. Lectures to the people by able men on a variety of subjects might be easily provided for at the annual sessions, without any impairment of the legitimate work of the sections. The Saratoga meeting, we are glad to note, manifested a decided tendency to fall in with this policy. Besides the popular character of the addresses of the President and of the Vice-Presidents, advantage was taken of the opportunities afforded by the locality to give a public entertainment, both thoroughly scientific and of interest to all classes. An evening was given to the mineral waters, and three of the ablest scientific men present made addresses of great interest on the different aspects of the subject. Professor Chandler, who has analyzed most of the waters, spoke of their composition, properties, and the characters of the different springs, illustrating his remarks by appropriate experiments, and extensive tabular statements. Professor Hall, the distinguished New York geologist, took up the relation of the rock formations to these fountains, and dwelt upon the history of those disturbances in the strata which have given rise to this extensive group of mineral springs throughout a valley which yields a new water at every boring. Dr. Sterry Hunt followed, with a most interesting and impressive address on those ancient conditions and transformations of the earth's crust which explain the genesis of this class of waters. By his profound studies of geological chemistry he was enabled to throw much light on the nature and origin of mineral springs; and, like the speakers who preceded him, he deeply interested the large audience who listened to his admirable exposition. It was altogether a happy illustration of what it is possible for the Association to accomplish in the way of first-class popular work.

Another consideration is pertinent here from this general point of view. The predominant movement of scientific thought is toward subjects which take a powerful hold of the popular imagination. Biology is the great science of the latter half of the nineteenth century. The mathematics, physics, and chemistry—the exploration of inorganic nature of the past three hundred years—are but the preparation for entering upon the exhaustive original study of the science of life. There was long a belief in its impossibility, and something like a dread of engaging with it; but that period is now past, and the advanced scientific mind of the world has entered in earnest upon the multitudinous problems offered by living beings, from invisible creatures, revealed by the microscope, up to man and his complex social relations. Science has slowly but steadily approached those elevated vital questions in which all intelligent persons have an acknowledged concern, and how completely these questions are now in the ascendant is shown by the leading discussions in both the American and the British Associations for the Advancement of Science. President Marsh considered the history of

the investigations into the earth's extinct life, and pointed out that the high ground of evolution has been gained, and that it is no longer an open question, but must be accepted for the guidance of future research; while all the tendencies of thought converge toward the conclusion which the future will realize, that inorganic and organic nature will yet become one. Dr. Ullman, also assuming the truth of evolution, enriches our biological literature with an elaborate essay on that remarkable substance, only made known in quite recent times, which turns out to be the common medium and substratum of all vital manifestations—the liquid protoplasm. Professor Mivart and Dr. Pye-Smith, in their inaugural addresses as Vice-Presidents, still further devote themselves to biology and natural history, while Powell and Tylor open the extensive subject of anthropology. Biological studies, of course, issue in the science of man, involving a broad series of questions, organic, psychological, developmental, racial, and social, and these questions now occupy the central arena of interest and debate. Anthropology has long been a prominent subject in the British Association, although for many years it had to battle for formal recognition and the important position that is now accorded to it. It has now come forward in the American Association, and the status conceded to it is sufficiently shown by the fact that the President-elect, who will preside at the Boston meeting next year, Mr. Lewis H. Morgan, is the first special representative of anthropology who has attained this honor.

These circumstances illustrate the powerful drift of contemporary science in the direction of those higher human questions which have claims upon intelligent people of all classes. So long as science was supposed to busy itself solely with distant, curious, and useless things, it was very naturally an object of thoughtless derision to minds occupied with pressing interests and claiming to be "practical." But these superficial sarcasms have lost their point in these latter days, when science is everywhere giving law to the practical, and is now addressing itself systematically to the most directly important of all subjects—the laws of life, and the nature of man and his institutions. This is the field that now most needs cultivation, and the Associations which are devoted to improvement and diffusion of accurate and trustworthy knowledge upon these subjects are entitled to the liberal patronage of the public.

LITERARY NOTICES.

A Sketch of Dickinson College, Pennsylvania: Including the List of Trustees and Faculty from the Foundation, and a more Particular Account of the Scientific Department. By Charles F. Himes, Ph. D., Professor of Natural Science. Illustrated by Engravings and by Photographs executed in the Laboratory. Harrisburg: Lane S. Hart. Pp. 155. Price, $2.

This neat little history of Dickinson College, with its portraits of the founder and of its leading presidents, its admirable photographs of the college buildings, and its illustrations of historic relics in its laboratory, will be much prized by all who are interested in the institution, and is by no means without instructiveness to general readers who care about the progress of education. Dickinson College, located at Carlisle, Pennsylvania, in the beautiful Cumberland Valley, was founded in 1783, and named after John Dickinson, Governor of the State, who was active in its establishment, and made liberal donations to it. Dr. Benjamin Rush was also deeply interested in the institution from the beginning, and labored zealously for twenty-five years in various ways to promote its success. The college has had a successful career and a creditable history, and includes among its alumni a President of the United States, a Chief Justice, with many judges, senators, Cabinet officers, Congressmen, and professional men of high rank. Among the distinguished men who

have occupied chairs in its Faculty may be mentioned Professor Henry D. Rogers; Professor Spencer F. Baird, now at the head of the Smithsonian Institution; and the celebrated Dr. Thomas Cooper, who subsequently became a judge and President of South Carolina College. Judge Cooper, as Professor Himes aptly remarks, was "one of the most remarkable products of the complexity of moral and intellectual forces of the closing quarter of the last century." He was a man of great erudition and independence, and a forcible writer. "A native of England, educated at Oxford, on terms of intimacy with Pitt, Burke, and other leading English statesmen, a resident of Paris during the four months of the Reign of Terror, and enjoying its excitement to the full, he was a radical in politics and a materialist in creed. A friend of Priestley, he shared with the latter his exile from his country, and enjoyed the use of his library and laboratory in Northumberland." Dr. Cooper was elected to the chair of Chemistry and Mineralogy in Dickinson College in 1811, and occupied it for four years. His introductory lecture on chemistry was remarkable for being one of the first scientific lectures published in the country. It was exhaustive, and displayed a wonderful range of information. The lecture itself filled one hundred pages, octavo, and its accompanying notes one hundred and thirty-five pages more. He purchased the telescope, air-gun, and burning-lens used by Dr. Priestley, which are carefully preserved in the college collection.

Professor Himes's account of the growth of the scientific department of the college is interesting as a chapter in the history of education. A revolution is there sketched which it is proposed to consummate in a century of collegiate experience. Although science was becoming active when the college was founded, yet scientific study as a part of education was in its infancy, while theology and cognate subjects were all-prevailing. The first question in regard to science, therefore, was, how it would affect religion. The first President was Dr. Nesbit, an able Scotch divine; and we are told that, on a visit to Governor Dickinson, an evening was spent in the discussion of the theological relations of science, in which Nesbit maintained that, "unless the grace of God produced a different effect, the more intimately men became acquainted with the works of nature, the less mindful were they of their great Author." Theology, therefore, led one way and science another; and yet, under the act of incorporation, of the forty members comprising the Board of Trustees more than one third were required to be clergymen; while every one of the fourteen presidents which the college has had has been a doctor of divinity. It is therefore to be expected that the college would favor the kind of learning that has proved of utility in the avocation of preaching. Important concessions have, however, been made in the direction of liberal studies. There is the ordinary four years' college course with its load of two dead languages, and which is probably much the same as it was a hundred years ago. But there is also a Latin-scientific course from which half the dead weight has been unloaded, and so it is brought into three years. But the scientific spirit has made great progress, as is shown by the fact that the centennial of the institution in 1883 is to be crowned by the dedication of a new and elegant building devoted entirely to scientific purposes.

Die Entwicklung des Menschengeschlechtes. Von Dr. Adelrich Steinach. New York: The Author, 122 Allen Street. 1878. Pp. 681. Price, $2.50.

This treatise forms the second volume of a "System of Organic Evolution," but the first volume, "The Evolution of the Plant and Animal World," is not yet published. The author adopts the Darwinian (or evolutionist) point of view throughout, but, unlike most of the German followers of Mr. Darwin, he adheres to that school of philosophy which is opposed to materialism. The present installment of Dr. Steinach's work, "The Evolution of the Human Race," is marked by profound learning and no small degree of originality. We have not space to review it at length, and must content ourselves with briefly indicating its contents. It is divided into three parts, entitled—"I. Man in Space"; "II. Man in Time"; and "III. The Evolution of Mind." In Part I. the author considers man in his relations to his environment, and strives to show how his mental and physical develop-

ment is conditioned by the forces acting upon him from without. In Part II. we have chapters on the "Origin of the Human Race"; "Prehistoric Relics"; "Centers of Creation"; and "Dispersion of the Human Race." Finally, in Part III., the author treats of "The Development of the Psychic Faculties"; "The Development of Language"; and "The Development of Civilization." Under the last-named head are chapters on the development of religious and moral ideas, of social relations, and of scientific and industrial activities.

THE PHILOSOPHY OF MUSIC. Being the Substance of a Course of Lectures delivered at the Royal Institution of Great Britain in February and March, 1877. By WILLIAM POLE, F. R. S., etc. Boston: Houghton, Osgood & Co. 1879.

IT is doubtful whether the musical public is in any degree aware of the revolutionizing contribution which contemporary scientific investigation is making to the theory of music, building a solid structure where before lay an interminable swamp of bad logic, fanciful speculation, and impossible metaphysics. Yet it was as long ago as 1863 that Helmholtz published his large epoch-making work ("The Sensations of Tone as a Physiological Basis for the Theory of Music"). Mr. Ellis in 1875 furnished an excellent English translation, adding several learned appendices of his own; and James Sully, Grant Allen, and others have written brief expository chapters and essays on Helmholtz's theory. A few years ago a society was organized in London for the study and propagation of the new order that had come into the complexities of musical theory. Mr. William Spottiswoode was president. It was at the invitation of Mr. Spottiswoode, as secretary of the Royal Society, that Mr. William Pole delivered at the Royal Institution of Great Britain the lectures on "The Philosophy of Music," which now appear in the book of that title.

This work for the first time places before the non-scientific reader a full, well-proportioned, and easily followed exposition of the new illumination which has fallen upon speculative music. This is a most important task, and to have performed it so well as Mr. Pole has done is a merit almost equal to that of original investigation. For the subject is burdened with a mass of historical and technical minutiæ that required the most careful sifting out of the non-essential; then came the task of leading the uninitiated reader to entirely new conceptions, and of eradicating or directly inverting many old and long-established ones. Altogether a more trying subject for the expository art could not have been found, and it is not too much to say that the musical reader may find in these twenty-one orderly chapters something beyond their subject-matter, viz., an excellent illustration of the systematizing and clarifying influence that scientific methods may have upon mental activity.

The author, preparing the way with a chapter on elementary acoustics, states the phenomena of overtones, and then shows their action in determining the tone-character or timbre of the various musical instruments. These overtones also constitute the natural basis for the scales, for melody, tonality, and harmony—in so far as these have a natural basis. For æsthetical influences, local, individual, and transitory, have played the largest part in giving to music its present form. The problem is to determine the parts played, on the one hand, by physical or physiological principles, on the other by æsthetical requirements, in that artistic growth which has from the simple Greek tetrachord developed modern music in all its complexity.

As to the origin of the diatonic scale, following Helmholtz always, the author believes the octave and its primary division into fifth and fourth to have arisen from the natural structure of a musical sound, which by its overtones embraces these three intervals. The octave, with its fifth and fourth, admitted of seven different divisions, the seven Greek modes. From these the requirements of early ecclesiastical music eliminated two modes, leaving five. The coming of harmony, under Palestrina, removed three more modes, unsuitable because of their paucity in concords; and the remaining two survive as our modern major and minor.* This gradual change, a genuine

* In showing this eliminative process an unfortunate mistake is made on page 134, the repetition of which on the following page seems to give it some weight. D forms with G not a perfect *fifth*, but a perfect *fourth*.

survival of the fittest, is made admirably clear by the graphical method of plotting the scale on paper; using the logarithms of the intervals for magnitudes. By the same method the complexities of the chromatic scale and of equal temperament are made easily comprehensible to careful reading.

After briefly considering the questions of time and form (Chapter XIII.) the *structure of music* (Part III.) is taken up. What use is made of the scales whose origin is traced in Part II.? What is due to natural laws, what to æsthetical influences? The position taken with regard to melody does not seem as strong as it might be. "The earliest forms of music probably arose out of the natural inflections of the voice in speaking." This is Spencer's theory. It is not mentioned that Darwin combats this, placing the origin of melody in the love-songs of man's early ancestors, before speech began; or that Helmholtz attributes the expressiveness of melody to its motion, which translates into vocal ordinates, as it were, the varying intensities of the emotions. It is shown in the "American Naturalist" (April, 1879, "Animal Music," etc.) that if the overtone structure of sounds has impressed itself upon the internal ear, the most easy progression of a melody will be along the intervals existing between overtones, viz., octaves, fifths, fourths, etc. This offers a much more natural basis for melody and scale origin than the theory of Helmholtz, repeated by Mr. Pole, according to which a certain connection is established between notes, an octave, a fifth, etc., apart by the *mind's recognition* of their possessing common overtones. This is a psychological, not a physiological basis.

In treating harmony, the natural element, viz., the rough beating of dissonant tones, is given due emphasis, and the dominance of æsthetical arbitrariness over this natural element fully shown. The fallacy of the *argumentum ad aurem*, so much used by theoretical musicians, is exposed. In the simplest elements of music the ear has no doubt been the guide, but the appeal to the ear is often carried too far. "We approve certain things not because there is any natural *propriety* in them, but because we have been accustomed to them, and have been taught to consider them right," and *vice versa* with our disapprovals. Chapter XVIII. greatly simplifies thorough bass by analyzing all the chords into their binary components, and investigating the harmonic character of these; not assuming in the usual way that every chord must have one root, but accepting Rameau's more rational view that there may be two. The last three chapters comprise harmonic progressions and counterpoint simply treated, and a good summary of the whole book.

The only improvements that could be wished are that the radical importance of the physical basis had been more firmly insisted upon, for, whatever may be the after-changes, this basis permeates and controls everywhere; and that the æsthetic influence had not been made to seem so entirely an incalculable matter of chance. This influence has laws of its own, and has been quite successfully investigated by James Sully in the two chapters of his "Sensation and Intuition" entitled "The Aspects of Beauty in Musical Form," and "The Nature and Limits of Musical Expression." These chapters, written in a most quiet and unassuming way, are rich in penetrating analysis made in full sympathy with the artistic side of music, yet with all the exactness and fertility of the scientific method. A brief showing of their trend would have enriched Mr. Pole's work, and have made his treatment more complete.

Laboratory Teaching; or, Progressive Exercises in Practical Chemistry. By Charles Loudon Bloxam, Professor of Chemistry in King's College, London; in the Department of Artillery Studies, Woolwich; and in the Royal Military Academy, Woolwich. Fourth edition, with Eighty-nine Illustrations. Philadelphia: Lindsay & Blakiston. Pp. 261. Price, $1.75.

The name of Professor Bloxam is the best assurance of the merit of this volume. The book does not presuppose any knowledge of chemistry on the part of the pupil, and does not enter into any theoretical speculations. It dispenses with the use of all costly apparatus and chemicals, and is divided into separate exercises or lessons with examples for practice to facilitate the instruction of large classes. The method of instruction followed has been adopted by

the author after twenty-three years' experience as a teacher in the laboratory, by which, as he says, he has been led to conclude that a knowledge of analytical chemistry, or the power of discovering the nature of unknown substances, is the first and often the only requirement of the great majority of learners, and that independently of the technical value of such knowledge, its acquisition forms a most valuable part of education by cultivating the powers of observation, and affording excellent examples of the application of logical reasoning in practical work.

Analysis of the Urine, with Special Reference to the Diseases of the Genito-Urinary Organs. By K. B. Hofmann, Professor in the University of Gratz, and R. Ultzmann, Docent in the University of Vienna. Translated by T. Barton Brune, A. M., M. D., Resident Physician, Maryland University Hospital, and H. Holbrook Curtis, Ph. B. With numerous Colored Plates. New York: D. Appleton & Co. 1879. Pp. 269. Price, $2.

It is gratifying to note the various indications of progress in popular journalism. While, as all can see, it is steadily advancing toward such lofty literary ideals as are exemplified by the writings of Macaulay and Froude, there is also encouraging promise that it is aspiring to a more elevated standard of purity and ethical taste. Especially when we observe a newspaper struggling and tempted, yet scorning all sordid considerations in the inflexible determination to maintain an exalted moral tone, so as never to wound the delicate sensibilities of its most fastidious readers, we are led to entertain glowing anticipations of the future of the American press. Our present enthusiasm is kindled by the refusal of the "New York Herald" to insert in its columns an advertisement of the book which bears the above title. But we can admire where it is impossible to imitate.

The importance of this subject has always been acknowledged in the medical profession. Hippocrates (400 B. C.) directed attention to the character of the renal excretion, and its changes of color, clearness, and its sediments, in connection with diseased conditions of the body; and he even endeavored to demonstrate the influence of various foods and drinks upon its constitution. The Arabian Avicenna (A. D. 1000) called attention to the fact that different external circumstances, as fasting, wakefulness, over-exertion, and strong emotions have an influence upon the character of the urine. Actuarius, in the thirteenth century, advanced the knowledge of the subject so far that it became an object of satire with poets and painters. Bellini (1675) investigated the proportion of solid constituents to the contained water. Willis discovered sugar in the urine, and Brandt obtained phosphorus from it. Rouelle discovered urea (1773). In 1770 Cotugno found pus in it; and in 1798 Cruikshank declared the relation of this condition to dropsy. In 1827 Bright proved the connection between kidney-disease and albuminuria; and Rayers's researches (1841) laid the foundation of our present knowledge of kidney-diseases. Since that time many observers have turned their attention to the subject; while the great advances of chemical, microscopical, and physical science have told effectively upon this branch of investigation. The urine indicates, at least very nearly, by its qualitative and quantitative changes the variation in tissue life, and it thus affords invaluable tests of the presence of disease; while its analysis, so far as it interests the practicing physician, can be made with simple apparatus. This volume, concise in form, and full of practical hints and valuable suggestions regarding both analysis and diagnosis, supplies a need that has been long felt by American students and physicians; while its merit is well attested by the fact that it appeared in three languages during the year of its publication.

A Dictionary of Music and Musicians (A. D. 1450–1879). By Eminent Writers, English and Foreign. With Illustrations and Woodcuts. Edited by George Grove, D. C. L. Part VII. London and New York: Macmillan & Co. Pp. 128. Price $1.25.

Another installment has come of this entertaining serial, filled with the art, science, history, biography, criticism, and miscellaneous erudition of music. The work is being faithfully executed, and keeps up its excellent character.

An Introduction to the Practice of Commercial Organic Analysis: Being a Treatise on the Properties, Proximate Analytical Examination, and Modes of Assaying the Various Organic Chemicals and Preparations employed in the Arts, Manufactures, Medicine, etc. With Concise Methods for the Detection and Determination of their Impurities, Adulterations, and Products of Decomposition. By Alfred H. Allen, F. C. S., Lecturer on Chemistry at the Sheffield School of Medicine, Fellow of the Institute of Chemistry of Great Britain and Ireland, Public Analyst for the West Riding of Yorkshire, the Northern Division of Derbyshire, and the Boroughs of Sheffield, Chesterfield, Barnsley, etc. Vol. I. Cyanogen Compounds, Alcohols and their Derivatives, Phenols, Acids, etc. Philadelphia: Lindsay & Blakiston. Pp. 360. Price, $3.50.

This useful volume is the first part of an ample treatise which will be carried out if the reception of the present portion justifies the compilation of the second volume. The author has been moved to its preparation by a conviction of the palpable deficiency in this branch of chemical literature. While manuals of inorganic analysis abound, books on organic analysis, the author avers, are chiefly conspicuous by their absence. He says: "It is a lamentable fact that while our young chemists are taught to execute ultimate organic analyses and to ring the changes on the everlasting chloro, bromo, and nitro derivatives of bodies of the aromatic series, the course of instruction in many of our leading laboratories does not include even qualitative tests for such every-day substances as alcohol, chloroform, glycerine, carbolic acid, and quinine. As a natural consequence of this neglect, the methods for the proximate analysis of organic mixtures and for the assay of commercial organic products are in a far more backward state than is justified by the great inherent difficulties of this branch of analysis.

"Having in my own practice as a consulting chemist repeatedly felt the need of a convenient hand-book containing all reliable information respecting the methods of assaying and analyzing organic substances in common use, I presume that others will have suffered similar experiences, and hence that a work on the subject will 'supply a want which has long been felt.'

"In the arrangement of the subject-matter I have ignored the more obscure relationships, and have preferred grouping the bodies treated of in a manner which it is hoped will be found convenient for practical reference, though such an arrangement has necessitated some inconsistencies."

The Relations of Mind and Brain. By Henry Calderwood, LL.D., Professor of Moral Philosophy in the University of Edinburgh. New York: Macmillan & Co. Pp. 455. Price, $4.

In the progress of modern psychology the organic side, or corporeal conditions of mind, has been brought into constantly increasing prominence, until now it is no longer denied that cerebral physiology is, if not a foundation, at least an essential part of mental science. But the necessity of having to mix up cells, fibers, blood capillaries, and protoplasmic pulp with subtile and refined mental operations, has been looked upon with great repugnance by the old-school metaphysicians. It has virtually divided them into two parties, one of which raises the cry of "Materialism!" and will have nothing to do with the new heresies; while the other accepts the situation, and is only anxious that the new views are not pushed too far. Among these more rational devotees of mental philosophy is Professor Calderwood, who, approaching the subject from the metaphysical side, has entered into the general inquiry of the physiological relations of the human mind. He thus explains the purpose of his book: "The object of the present work is to ascertain what theory of mental life is warranted on strictly scientific evidence. The order followed is to consider—1. The latest results of anatomical and physiological research as to the structure and functions of the brain; 2. The facts in human life unaccounted for by anatomical and physiological science, and requiring to be assigned to a higher nature. On the side of mental philosophy it must be recognized that analysis of consciousness can not be regarded as affording a complete survey of the facts of personal life. On the other hand, it is clear that the known facts connected with cerebral action do not include familiar phases of mental activity. If we allow ourselves to be engrossed with physiological investigations as to brain, we restrict our attention to a single class of

facts, and become unable to take a view of human life as a totality. The whole range of evidence must be traversed if we are to secure an harmonious representation of the constitution of human nature." The book has not been produced in the pure spirit of science, but under a bias, and to sustain a foregone conclusion; yet the work is done with ability, and will be useful.

The Round Trip by Way of Panama, through California, Oregon, Nevada, Utah, Idaho, and Colorado. By John Codman. New York: Putnam's Sons. 1879. Pp. 331. Price, $1.50.

This is a truly valuable book of travel. The author is a keen observer of man and of nature; and, moreover, he is a skilled literary artist. He sees with his own eyes, and not through the eyes of a guide-book writer, and he carefully eschews the commonplace. He writes of the railroads, commerce, agriculture, mining, scenery, and populations of the great States and Territories visited on the "Round Trip."

Lectures on the History of England. By M. J. Guest. London: Macmillan. 1879. Pp. 598, with Maps. Price, $1.75.

The author offers in his preface an apology for adding to the already over-large number of "Histories of England." Having to deliver lectures to men and women (working people, presumably) on English history, he found, on beginning to prepare his lessons, "no one book which was not either too learned, too copious, too trivial, or too condensed." Plainly, then, there was still room for one history more. Special indebtedness is acknowledged to Green's "History of the English People."

A Complete Scientific Grammar of the English Language. By W. Colegrove. New York: The Authors' Publishing Co. 1879. Pp. 362.

In the preface to this book it is said that "at present English grammar is in the same condition in which Copernicus found astronomy." The author appears to be pretty confident that his work has established the "reign of law" in this chaos, and that henceforth grammar is to rank as a "science" in the strictest sense of that term.

Free Religious Association. Proceedings at the Twelfth Annual Meeting of the Free Religious Association, held in Boston, May 29 and 30, 1879. Boston: Free Religious Association. Pp. 79. Price, 25 cts.

The "Free Religious Association" is one of the extreme reactions against the restrictive spirit of ecclesiasticism which is still dominant in modern society. That spirit has unquestionably declined in power with the rise and advance of scientific thought. Protestantism was a revolt against the tyranny of the older religious organizations. The liberal Christianity of our own century was, again, a revolt against the spiritual repressions of Protestantism. And now "free religion" carries on the liberating work still further by rebelling against the restrictions of liberal Christian theology. Something is gained to freedom of religious thought at each step, and the advance movement is ever engaged upon a wholesome and necessary work. The "Free Religious Association" announces its objects to be, to promote the practical interests of pure religion, to increase fellowship in the spirit, and to encourage the scientific study of man's religious nature and history. It avows no creed, but leaves each individual member responsible for his own opinions alone, and declares that nothing in its constitution shall ever be construed as limiting membership by any test of speculative opinion or belief, or as interfering in any other way with that absolute freedom of thought and expression which is the natural right of every rational being.

It would seem to be impossible to go further in the declaration of religious freedom. Nothing remains to be gained on that score. Yet the Association does not at all admit that it is therefore out of business. It has important ethical objects to secure, and therefore plenty to do. In fact, free religion itself is held to be a means of attaining exalted moral ideals, and from this point of view it has before it endless occupation and a positive basis of union. Beliefs, views, doctrines now come in order, and there seems to be the necessity of something resembling a creed or declaration of convictions. The need of some groundwork, or platform, or avowal of doctrine that can furnish a common basis and give

coherency and efficiency to the movement was well presented by Mr. Francis E. Abbott in his address, which contains the following passage:

"The first and greatest need of all is that of a commanding and systematic *philosophy* of morals, of religion, and of life. We have not got it yet. It is still to be made. We have only hopes of it—only glimpses of it. The first serious task before us is to elaborate that philosophy. We don't know yet the power of system. We have been taught to despise system. We have been taught that system runs to dogma, that dogma runs to death, and that if we are radicals, if we are free religionists, we must steer clear of system above all. Why, friends, is not the universe a system? Is not the solar system—that part of the universe in which we live—a system? Is not science a system, more and more, as it obeys its own ideal? Thought must be systematic or it is powerless; and free religion will be powerless until it has learned the great lesson of nature, and become systematic. That is what philosophy means. We must introduce order, harmony, unity, sublimity into our thoughts, or we shall try in vain to affect the world's life, from this platform or from any other. First of all, let us comprehend the one great need of free religion, the need of intellectual unity, order, and concentration in our thinking. When we have got that, when we have reduced our principles to system, then we shall have unsealed the fountain-head, as it were, of all noble enthusiasm and all mighty power in the world—*and not till then.*"

Life and Work of Joseph Henry. By Frank L. Pope, Vice-President of the American Electrical Society, Member of the Society of Telegraph Engineers, etc., etc. New York: D. Van Nostrand. Pp. 31.

This pamphlet is reprinted from the "Journal of the American Electrical Society," and it is especially interesting and useful as giving a clear account of Professor Henry's electrical and electro-magnetic investigations. We want a more considerable work in relation to the career and influence of Professor Henry, but in the absence of such a volume this paper will prove most instructive.

National Education in Italy, France, Germany, England, and Wales, popularly considered. By C. W. Bennett, D. D., Professor of History, Syracuse University. (Originally published in the "Northern Christian Advocate.") Syracuse, N. Y. Pp. 28. Price, 15 cents.

To those who are unfamiliar with the state of European education this little monograph will be found worthy of attention. It is very brief, but gives a good general view of the subject, and may serve to dissipate some of the prejudices that have grown up in many minds against foreign educational systems under the patriotic notion that America leads the world in education.

Roman Catholicism in the United States. New York: The Authors' Publishing Co. 1879. Pp. 190.

The Authors' Publishing Company, in their announcement of this book, recommend it as compact of "fact and logic, pure, clear, and irresistible." The impartial reader, however, will find it in nothing different from the average of works of its class. Its dominant idea is that, unless we "do something," the Pope will soon be master of the situation in America, and all our free institutions will be suppressed. The book does not contain a single idea that has not been proclaimed already ten thousand times from the rostrum and in the anti-Popery press. A less passionate survey of the situation might have developed grounds for not despairing of the commonwealth. There is a spirit of skepticism abroad among the people which will not permit the reëstablishment of ecclesiastical despotism, whether Protestant or Papal.

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Hygiene and Public Health. Edited by A. H. Buck, M. D. Two vols. New York: W. Wood & Co. 1879. Pp. 792 and 657.

The Silk Goods of America: Recent Improvements and Advances of Silk Manufacture in the United States. By W. C. Wyckoff. New York: Van Nostrand. 1879. Pp. 120. $1.50.

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the Tin-Copper Alloys. R. H. Thurston, Chairman of Committee. Washington: Government Printing-Office. Pp. 582.

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History of the English Language. By T. R. Lounsbury. Same publishers. 1879. Pp. 381. $1.

History of American Politics. By A. Johnston. Same publishers. 1879. Pp. 284.

Science Lectures at South Kensington. Vol. II. London: Macmillan. 1879. Pp. 400. $1.75.

Easy Lessons in Popular Science. By J. Monteith. New York: Barnes & Co. 1879. Pp. 255, with Illustrations. $1.

A Defense of Philosophic Doubt. By A. J. Balfour. London: Macmillan. 1879. Pp. 363. $3.50.

Summer-Savory, gleaned from Rural Nooks. By B. F. Taylor. Chicago: Griggs & Co. 1879. Pp. 212. $1.

The Science of the Bible. By M. Woolley, M. D. Chicago: The Author. 1879. Pp. 613. $4.00.

Elementary Lessons on Sound. By Dr. W. H. Stone. London: Macmillan. 1879. Pp. 203. 80 cents.

Sequel to "Essays." By C. E. Townsend. New York: Somerby. 1879. Pp. 161.

School Cookery Book. By C. E. G. Wright. London: Macmillan. 1879. Pp. 158. 35 cents.

"Journal of the American Chemical Society." Vol. I., No. 6. Pp. 80.

Remarkable Groups in the Lower Spectrum. By S. P. Langley. Pp. 14, with Plates.

Temperature of the Sun. By the same. From "Proceedings of the American Academy of Arts and Sciences." Pp. 8.

Wonders of Light and Color. By E. D. Babbitt. With Illustrations. New York: Babbitt & Co. 1879. Pp. 40. 25 cents.

A Few Well-established Facts in Connection with Squint. By J. J. Chisolm, M. D. Baltimore, Maryland, "Medical Journal" print. 1879. Pp. 15.

Vowel Theories. By A. G. Bell. From "American Journal of Otology." 1879. Pp. 20.

How Infant Mortality may be lessened. Madison, Wisconsin: Atwood print. Pp. 8. 1879.

Emotional Prodigality. By Dr. C. F. Taylor. Philadelphia: S. S. White. 1879. Pp. 16.

Career of Jesus Christ. By Dr. M. Woolley. Streator, Illinois: The Author. Pp. 53. 30 cents.

Examination of the Color-Sense of 3,040 Colored Children. By Dr. S. W. Burnett. Pp. 9.

Responsibility of the Partially Insane. By Dr. T. L. Wright. Pp. 15.

Recession of the Falls of St. Anthony. By N. H. Winchell. From "Quarterly Journal of the Geological Society." 1878. Pp. 16.

On the Word God. By. Dr. M. Woolley. Streator, Illinois: "Free Press" print. 1878. Pp. 22. 10 cents.

Hints toward a National Culture for Young Americans. By S. S. Boyce. New York: Steiger. 1879. Pp. 67.

Chlor-stannic Acid. By J. W. Mallet. From "Journal of the Chemical Society." 1879. Pp. 3.

The Progressive Attributes of Inanimate Matter. By Dr. A. J. Howe. Pp. 8. Autopsy of an Elephant. By the same. Pp. 8.

Sanitary Condition of Montreal. By F. P. Mackelean. Montreal: Lovell Co. print. 1879. Pp. 41.

POPULAR MISCELLANY.

The Saratoga Meeting of the American Association for the Advancement of Science.—The Saratoga meeting of the American Association for the Advancement of Science was very numerously attended by members from all parts of the United States. The presence of very many of the foremost scientists of the country was a reassuring evidence of the high esteem in which the work of the Association is held by those whose pursuits and attainments best qualify them to judge of its value. The first public session was held in the Town Hall of Saratoga, on Wednesday, August 26th, Professor O. C. Marsh, the retiring President, in the chair. The President-elect, Professor George F. Barker, having been duly installed, an address of welcome was presented to the Association by Dr. McEwen, chairman of the local committee, on behalf of the citizens of Saratoga. The President made a graceful response to this address, expressing the thanks of the members of the Association for the cordiality with which they were received. Referring to the labors of scientific men, and the aims and purposes of the Association, he said that "the American Association is a scientific body, and, using the word science in its widest sense, we claim that only that knowledge which is actual should be garnered as wheat, though much undetermined material may be collected for investigation. It is the more or less crude speculation, rather than the established fact, which tends to bring science into discredit. Undoubtedly, in advancing into an unknown country progress must be slow and results more or less doubtful, until the ground has been more thoroughly explored, and the relations of things have been established. But the antagonism of varying views and the cross-questioning of opposing opinion soon bring the truth to light, and fix it as an integral part of science.

"But our Association has for its object to advance science not only by the discovery of new truth, but also by the diffusion of that already known. To this end it extends a cordial recognition to all organizations of whatever sort, whose objects are akin to its own. Being itself national in character, it gives its indorsement to all local enterprises,

and stands ready to assist them in any legitimate way. Whether it be a State geological or topographical survey, an academy of science, or association or individual seeking to unravel nature's secrets, the Association desires to strengthen their bonds and to uphold them in the communities where they are located. Its province is to awaken an interest in pure science; or, where such interest already exists, to develop it to the full. It invites all interested in science to its membership, and opens its sessions to all comers. That its periodical and migratory meetings, in the words of the constitution, have actually done what they were intended to do, have promoted intercourse between those who are cultivating science in different parts of America, have given a stronger and more general impulse and a more systematic direction to scientific research, and have procured for the labors of scientific men increased facilities and a wider usefulness, no one who has watched its history can doubt."

The following abstracts of the more interesting papers read at the meeting are condensed from the reports published in the "Times" and the "Tribune":

The Orang-outang at Home.—Mr. William T. Hornaday read a paper on the orang-outangs of Borneo. The author spent several months last year in that island, studying its simian fauna and collecting specimens. Each individual of the Bornean orangs, he said, differs from its fellows, and has as many facial peculiarities belonging to itself alone as can be found in the individuals of any unmixed race of human beings, as the Chinese or the Japanese. The faces of the more intelligent orangs are capable of a great variety of expression, and in some the exhibition of the various passions is truly remarkable. The author had in his possession in Borneo four young living orangs. Three were dull and impracticable, but the fourth was singularly intelligent and docile; the development of its forehead and entire cranium "would have been quite alarming to an enemy of the theory of evolution." This specimen was a male infant seven or eight months old, twenty-two and a quarter inches in height, thirty-seven inches in expanse of arms, and fifteen and a half pounds in weight. He exhibited fully as much intelligence as any child under two years of age, with all the emotions of affection, dislike, anger, fear, etc. When teased beyond endurance he would first whine fitfully, but, if the teasing were continued, he would throw himself upon the floor, kicking and screaming and catching his breath like a child. Touching the habits of adult animals, Mr. Hornaday said that the male orangs are much given to fighting, their huge canine teeth being their principal weapons of offense. One of the specimens exhibited by the author bore the scars of many a fierce contest. Large pieces had been bitten out of both lips, and his middle fingers had been bitten off. He had also lost two of his toes in this way. The orang's nest consists of a quantity of leafy branches broken off and piled loosely in the fork of a tree. The orang usually selects a sapling, and builds his nest in its top. Sometimes the nest is fully three feet in diameter, but usually not more than two, and quite flat on the top. There is no weaving together of branches. On this bed the orang lies, reposing on his back, his long arms and short thick legs thrust upward, and firmly grasping the branches within his reach.

Edison's Electro-Chemical Telephonic Receiver.—An exhibition of Edison's electro-chemical telephonic receiver was given before the Association in the Town Hall, and was prefaced by a very clear and succinct explanation of the principles involved in different kinds of telephones, by Professor Barker. Mr. Edison was present, and offered an explanation of his new instrument. Apparently, it is simply a small box provided with a crank, and looking like a coffee-mill. Its working is based on the fact that, when a piece of metal is pressed upon a chalk cylinder saturated with phosphate of soda, and a current of electricity is passed through the metal, there is no friction between the chalk and the metal, no matter how great the pressure. But, the instant the current is checked, the pressure applies and causes friction. In the new receiver there is a chalk cylinder which is made to turn by means of a crank. Upon the cylinder rests a metallic arm or bar that is attached at the opposite end to the cen-

ter of a metallic diaphragm. This arm or bar is a lever, and multiplies the scope of vibration. The current which is transmitting a message vibrates the diaphragm. In proportion to the strength of the wave of electricity on the wire, the friction between the arm and the cylinder is varied, and the amount of sound produced is varied in like proportion. The sound transmitted is thus magnified. The person who talks furnishes the power, but the person who is at the receiving instrument controls the power, and the message only becomes audible when the chalk cylinder is rotated. This receiving instrument has no connection with the wires that transmit the message, owing to defects not yet overcome in the manufacture of telegraph wires. It takes its message through a coil placed in close proximity to a second coil which is in communication with the ordinary telegraph wire. Could the coil be dispensed with, the sounds could be still more magnified than they are with the present arrangement. The instrument exhibited was only an experimental model; nevertheless it transmitted messages which were heard by the whole audience, numbering fifteen hundred persons.

Experiments on the Living Brain.—At the close of one of the daily sessions of the Association, Professor Burt G. Wilder gave illustrations of some of the experiments of Ferrier on the brains of living animals. Having by the use of ether reduced a cat to the state of insensibility, Professor Wilder laid bare the surface of the animal's brain by removing the roof of the skull. On the wall was hung a diagram of the brain, with certain regions of it designated by figures. A chart stated what movements would be made by the cat, as these different regions of its brain were successively touched by the terminals of a weak electric current, and in every case the movements occurred precisely as laid down in the chart. Thus, when the place on the brain answering to that marked "1" in the diagram was touched, the opposite hind-leg of the animal was advanced as the chart said it would be. When "4" was touched the opposite fore-leg moved as if to strike, being first drawn back. Again, the animal was made to scream, spit, and lash its tail, by similar means.

Insect-Destruction of Evergreen-Trees.—Professor S. H. Scudder gave to the members of the Entomological Club, an annex of the Association, an interesting account of the destruction of the pine-forests of Nantucket Island. Formerly, he said, the island was well wooded; but, during the war with England in 1812, the inhabitants, cut off from intercourse with the mainland, were reduced to such straits for fuel that they burned every tree. Some years ago plantations of pines were begun, and now a large portion of the island is covered with pines and scrub-oaks. Now, however, sure though slow destruction threatens the young forest through the agency of a small moth, whose larvæ attack the leaf-buds. This moth is closely allied to the *Retinea silvestrina* of Europe, but probably belongs to a distinct species. It bores into the tip of each terminal bud, and saps the life of the tree. Every pine on the island, Mr. Scudder says, is affected, and he sees no way to save the forest. Other members reported the presence of *Retinea* and allied species of insects in different parts of the country. Professor J. H. Comstock had found a large species of *Retinea* destroying pine-trees in western New York. Mr. Bassett said that a few years ago the white pines and Norway spruces in Connecticut were threatened with destruction by a moth, but the danger passed away. Professor Riley said that the junipers on Long Island are attacked everywhere by a destructive moth, and that all the foreign imported evergreens suffered in like manner. He recommended the use of Paris-green as a means of exterminating the pests.

The Constitution of the Sun.—Professor S. P. Langley, Vice-President, addressed Section A upon the progress of solar physics. Even after the invention of the telescope, he said, astronomy was more concerned with the motions of the heavenly bodies than with their physical nature. With the aid of mathematics, the great law of gravitation was ascertained, and the movements of the heavenly bodies thenceforth could be predicted. But great questions still remained untouched. Life on the earth depends on the great central fire, the sun. What is that fire? What are its sources? How long will it continue? With almost the sole

exception of the Herschels, a few years ago nobody attempted to solve these questions. Mellōni was among the first to give the subject serious attention. He used the thermopile and the galvanometer in his researches. Fraunhofer prepared the way for the spectroscope, and in 1860 the employment of that instrument by Kirchhoff opened the pathway of the modern science of solar physics. At first we knew little more than that the sun was a hot globe, with occasional spots on its surface; now the work has been divided into special fields of research. Professor Langley here recounted, in considerable detail, the labors of the great modern physical astronomers, but our space is too circumscribed even to give a synopsis of his remarks. In concluding, he pointed out the practical value of many of these researches. The direction in which to look for the resolving of elements into simpler forms may be indicated by solar analysis. The real nature of terrestrial elements may thus be ascertained. The problems of meteorology may find their ultimate solution in studies of the sun, and enable us to predict the years of dearth or plenty in our harvests. But as yet none of us are able to prophesy the weather for even the coming week from our knowledge of the sun. A more promising field of utility is opened in the construction of solar engines. These may be made at some future day to employ the sun's heat to better advantage than we now use steam-power. At present our science teaches us to look for a period, in the far-distant future, when our sun's fires shall become extinct, and earth a frozen orb. The glacial era tells us of a previous epoch, when life may have been equally restricted by cold, and we are thus taught that the human race is the creature of yesterday, and can not endure for ever.

The Coal of the Future.—In a paper on the anthracite coal-fields of Pennsylvania, Mr. P. W. Sheafer estimated the production of that kind of coal in 1820, when anthracite mining was begun, at 365 tons; it is now 20,000,000 tons per annum. According to Mr. Sheafer, only one third of the coal goes into market; the other two thirds is wasted, being lost in the mines and in preparation. The maximum product he estimated at about 50,000,000 tons per annum, and, at the present rate of increase, this limit will be reached in the year 1900. At that rate the anthracite coal-fields would be exhausted in 186 years, say in the year 2065. Then we must have recourse to our bituminous coal-fields, whose area reaches the enormous extent of 200,000 square miles, or four hundred times the area of the anthracite. The competition between the several anthracite coal companies, and between them and the producers of bituminous coal, will always keep the price moderate. Mr. Sheafer doubted if Great Britain could much increase its present enormous product of 136,000,000 tons, but at her present rate of increase she will have exhausted her coal at about the time when our anthracite resources are at an end.

Origin of Certain Mound-Formations in California.—A correspondent of the "Monthly" in the number for December, 1878, described the curious hummocky appearance of the surface of the ground in the Yosemite Valley, and expressed a wish to have the phenomenon explained. It appears that a similar surface-conformation is to be seen in many other parts of California, and Dr. G. W. Barnes offers an explanation of its origin in a paper in the "American Naturalist," on "The Hillocks or Mound-Formations of San Diego." According to Dr. Barnes, these mounds, in their most common type, may be described as rounded eminences or knolls, rising from one to four feet above the surrounding surface or the depressions between them, and ranging from ten to fifty feet in diameter. Each mound, he says, marks a spot where formerly grew a shrub, or cluster of shrubbery, which served to fix its location, and which exercised an important influence in the successive stages of its development. Dust set in motion and borne along by the winds is arrested by the shrub, and together with its fallen leaves accumulates within and around it, often nearly enveloping the whole plant. The gopher, subsisting upon roots and preferring for its operations the loose soil about them, is, in exceptional cases, an adjunct of the wind in heaping up material about the plant. While the loose earth of which the deposit is composed is

protected by the branches and foliage of the plant, the more solid earth beneath is also protected from the wash of rain by its massive roots (the author refers to the roots of *Simmondsia Californica*), while all around erosion goes slowly on, facilitated by the peculiar susceptibility of the soil to wash. In the course of time the plant dies—is smothered by the drift which nearly covers it, or is destroyed by the annual fires. Thus deprived of its protection, the winds in turn and the rains which fall upon it wear down the top of the loose deposit, and to some extent widen its base. While this is going on the surrounding earth is being continually lowered by the action of water. The wash being greater at the base than at the summit, its effect is to perpetually maintain or increase the prominences. Such is the explanation of these hummocks offered by Dr. Barnes.

Steadiness of the Electric Light.—In employing the electric light for projection on a screen, two chief points are to be considered, viz., brilliancy of illumination and steadiness of the light. When the source of electricity is sufficient, the first of these ends is easily obtained. The second is not so easy of accomplishment. The difficulty here met with is pointed out in the "American Journal of Science," by Mr. H. W. Wiley, who also proposes a method of obviating it. The carbons burn away so rapidly that when no mechanism is present to produce alternating currents the electric arc is constantly passing out of the focus. Often, too, Mr. Wiley finds that when the current is quite strong the arc will extend itself momentarily between points as far as a centimetre from the end of the carbons. To prevent this too rapid combustion of the carbons, he coats them with a thin film of copper—a plan well known in France, though seldom tried here. With this coating of copper the carbons work satisfactorily for a short time; but soon the film is oxidized, and the combustion is as rapid as before. Mr. Wiley therefore protects the copper from oxidation by covering the carbons (after copper-plating) with a film of plaster of Paris. After the plaster has set, the edge of the carbon which is to be turned toward the condenser is carefully denuded of its plaster covering, which is also cut away till quite thin on the adjacent surfaces. These precautions are taken so that the plaster may not interfere with the radiation of light in the direction of the condenser. The copper surface at the end of the carbon being uncovered, it is fastened in the holder in the usual way. The light now produced is steady and the combustion of the carbon slow. The film of plaster melts gradually as the point is consumed, and thus never interferes with the illumination. The points of both the negative and positive carbons remain blunt, and there is no wasting away of the stem. A carbon prepared in this way will last at least ten times as long as one used in the ordinary way. The chief advantage, however, is found in the comparative steadiness of the light.

The Shape of the Earth.—There is in England a man named Hampden who believes the earth is flat, and is sorely tried because he can not win all his fellows to this opinion. He is fond of conducting controversies on this subject in the public press, and evidently derives great satisfaction from every contest, being a member of that fraternity who are "of the same opinion still," however convincing may be the facts and arguments which are adduced against their peculiar ideas. Mr. R. A. Proctor has lately found time to engage in a published correspondence with this interesting person, and now proposes to settle the matter by an experiment. It appears that, some years ago, Hampden agreed to forfeit a certain sum of money if the result of a similar experiment should prove to be adverse to his opinion. He lost the money. To this experiment Mr. Proctor alludes in the opening sentence of his challenge, which is as follows: "In the Bedford Canal experiment, the result of which cost Mr. Hampden so much loss and annoyance, he distrusted the evidence of the referee's eyes, and considered also that there should have been three boats in line, one at each end and one in the middle of the long distance. Now, as nothing would be easier than to photograph three boats so arranged on a clear, quiet day, and as the collodion-film can neither be *deceived* nor *lie*, I can not understand why he should not try that simple

experiment, instead of calling me and other students of astronomy by bad names. To encourage him further, I will undertake to pay the hire of suitable photographic apparatus and all expenses of a qualified operator, at any convenient place in the neighborhood of the Bedford level, if any one of the negatives should show the three boats (at distances, say, of one mile, three miles, and five miles from the camera) at the same, or anything near the same, level. Mr. Hampden will observe that I reply to his questions by simply denying that the facts are such as he alleges, and by showing a convenient way in which this matter may be put to the test, once for all."

Poison-Proof Animals.—The action of the solanaceous alkaloids on the rodents has been investigated by Professor Heckel, of Marseilles, with a view of ascertaining the conditions which determine the remarkable immunity which those animals enjoy against poisoning by the substances named. Not only the rabbit and the pig, but rats can with impunity take belladonna, and the alkaloids of *Datura stramonium* and *D. tatula*. The alkaloids of black and white *hellebore*, too, are innocuous to the rodents. Professor Heckel's researches show that the rabbit and Guinea-pig may be fed for a long time with the leaves and even with the roots of the poisonous *Solanaceæ* without detriment, and that the rat bears very well the addition of these vegetables to its ordinary food. The immunity of the rabbit and Guinea-pig is so great that M. Heckel has been able to bring up several generations on this food, giving them during the summer the leaves exclusively, and during the winter mixing dried powdered leaves and roots with equal parts of other food. It is his opinion that the effect of poisons lessens in proportion as animals recede in organization from man.

Opium-Eating and Intemperance.—It is asserted by Dr. Moffat that one result of the early closing of public-houses in England is an increased consumption of opium and laudanum. It would be an interesting subject of inquiry to ascertain what is the exact ratio between the decline of "intemperance" and the growth of opium-consumption. Dr. Moffat in 1874 first became impressed with the belief that the consumption of opium was more general among the working classes than was commonly supposed; and set to work to ascertain the truth. The druggist in a certain mining village informed him that since the public-houses were closed at 10 P. M., his sales of laudanum have increased from a very small quantity to two quarts per week. Similar reports were received from druggists in other mining villages. Nor is it only in opium and chloral hydrate that there is increased consumption. There are many soporifics and stimulants taken in place of beer, viz., absinthe, cologne-water, tincture of rhubarb, mixture of opium and chloroform, chlorodyne, and the ethers. In Ireland there has been a great increase in the quantity of sulphuric ether consumed since the public houses in that country were closed on Sundays.

Statistics of Population. — In "Petermann's Mittheilungen" the population of the globe is estimated, for 1877, at 1,429,145,000 souls, occupying a superficial area of 134,460,000 square kilometres. Inhabitants are distributed among the continents as follows: in Europe, 312,398,480; in Asia, 813,000,000; in Africa, 205,219,500; in Australia and its islands, 4,411,300; in America, 86,116,000. Between 1875 and 1877 the whole population increased by 42,000,000. This increase, however, does not depend on the very great excess of births over deaths, but is the result of more accurate enumeration, and more extended knowledge of various localities. The populations of European countries, in 1877, were: Belgium, 5,336,185; Holland, 3,865,456; England, 34,242,966; Italy, 27,769,475; Germany, 42,727,360; France, 36,905,788; Switzerland, 2,759,854; Austria, 37,350,000; Denmark, 1,905,000; Spain, 16,526,511; Portugal, 4,057,538; Greece, 1,457,894; European Turkey (exclusive of the tributary states), 9,573,000; European Russia, 72,392,927; Sweden and Norway, 6,237,268. As regards the proportion of the sexes, there were to 1,000 men in the Canary Islands 1,208 females; in Sweden, 1,064; Switzerland, 1,045; England, 1,043; Germany, 1,037; Austria, 1,024; Russia, 1,022; Spain, 1,016; France, 1,007; Italy, 989; Belgium, 985; Greece,

983; North America, 978; Brazil, 938; Egypt, 1,025; Japan, 971; Siberia, 934.

Dimensions of the Esquimau Skull.—Though the Esquimaux are generally below the middle stature of man, their heads are as large as those of more favored races. According to Professor Flower, the average capacity of an Esquimau skull (male) is 1·546 cubic centimetres (94·3 cubic inches), almost exactly the same as the average English skull of the lowest class, while it exceeds by seventy-one cubic centimetres the average of seventy-four modern Italian skulls. This large size of the brain seems not necessary to be connected with intellectual development. Another distinctive characteristic of the Esquimau skull, as pointed out by Professor Flower, is its great length and narrowness, especially in the upper part. The base is fairly broad, and the mastoid processes well developed; but, instead of expanding upward to the parietal region, it narrows, and, toward the median line above, contracts so rapidly that the upper part of the skull has the form of the roof of a house. The affinities of the Esquimau race are declared to be more with the inhabitants of northeastern Asia than with the American Indians; and probably they are derived from the same stock as the Japanese.

The Climate of Mogador.—From the journal of a tour in Marocco by Dr. Hooker and others, recently published, we learn that the climate of Mogador is one of the most equable known in the temperate zone. This fact is shown by careful observations, made by M. Baumier, covering a period of eight years. The lowest temperature observed was 50·7°, the highest 87·8°. The mean temperature for the hottest year was 68·65°, the mean for the coldest year was 65·75°. If we compare the mean temperature of summer with that of winter, we find a difference of 10° only, the mean for summer being about 71°, the mean for winter being 10° less, or about 61°.

It is stated that phthisis is almost completely unknown among the people of this part of Africa. A resident physician, Dr. Thevenin, had found five cases only in ten years, and of these the disease was in three cases contracted elsewhere. Europeans suffering from lung-diseases find speedy relief on removing here.

In Algeria, which has some fame as a health resort, the range of the thermometer is much greater, and the climate is less suited to delicate constitutions. The same is true of the climate of Egypt, and of Madeira (Funchal).

The total rainy days in a year at Mogador is forty-five. If a fog occurs, it is rapidly dissipated as the morning advances, and the desert-wind, so distressing over many parts of northern Africa and southern Europe, is scarcely felt, the period of its prevalence being only about two days in a year.

The northeast trade-wind, which prevails two hundred and seventy-one days in each year, and the proximity of the great Atlas chain of mountains, greatly modify the climatic conditions. There seems no reason to doubt that invalids will find Mogador a most favorable place of resort. At present, however, the social conditions in which a stranger finds himself in this Moorish city are a serious drawback. There is want of society, of occupation, and amusement. But Dr. Hooker well observes, "One interested in any branch of natural history may find constant occupation in a climate where not half a dozen days in a year but may be passed agreeably out of doors."

Remarkable Luminous Phenomenon.—Commander Pringle, of the British naval ship Vulture, makes report of a singular phenomenon observed at sea, at about 9·40 P. M., on May 15th, in latitude 26° 26′ north, and longitude 53° 11′ east. It was a clear, unclouded, starlight night, Arcturus being within some 7° of the zenith, and Venus about to set. The wind was northwest, sea smooth, ship on starboard tack, heading west-southwest, and going three knots. Commander Pringle writes, "I noticed luminous waves or pulsations in the water, moving at great speed, and passing under the ship from the south-southwest. On looking toward the east, the appearance was that of a revolving wheel with center on that bearing, and whose spokes were illuminated, and looking toward the west a similar wheel appeared to be revolving, but in the oppo-

site direction. I then went to the mizzen-top (fifty feet above water), and saw that the luminous waves or pulsations were really traveling parallel to each other, and that their apparently rotatory motion, as seen from the deck, was caused by their high speed and the greater angular motion of the nearer than the more remote part of the waves. The light of these waves looked homogeneous and lighter, but not so sparkling as phosphorescent appearances at sea usually are, and extended from the surface well under water; they lit up the white bottoms of the quarter-boats in passing. I judged them to be twenty-five feet broad, with dark intervals of about seventy-five between each, or one hundred from crest to crest, and their period was seventy-four to seventy-five per minute, giving a speed, roughly, of eighty-four English miles an hour. . . . I could only distinguish six or seven waves . . . I observed no kind of change in the wind, the swell, or in any part of the heavens, nor were the compasses disturbed. A bucket of water was drawn, but was unfortunately capsized before daylight. The ship passed through oily-looking fish-spawn on the evening of the 15th and morning of the 16th."

An Imported Sovereign.—In a communication to the Academy of Natural Sciences of Philadelphia the Rev. Mr. McCook records an instance of the adoption of a fertile queen of *Crematogaster lineolata*, a small black ant, by a colony of the same species. The queen, which had been taken on April 16th was on May 14th introduced to workers of a nest taken on the same day. The queen was alone within an artificial glass formicary, and several workers were introduced. One of these soon found the queen, exhibited much excitement, but no hostility, and immediately ran to her sister workers, all of whom were presently clustered upon the queen. As other workers were gradually introduced, they joined their comrades, until the body of the queen (who is much larger than the workers) was nearly covered with them. They appeared to be holding on by their mandibles to the delicate hairs upon the female's body, and continually moved their antennæ caressingly. This sort of attention continued until the queen, escorted by workers, disappeared in one of the galleries. She was entirely adopted, and thereafter was often seen moving freely, or attended by guards, about the nest, at times engaged in attending the larvæ and nymphs which had been introduced with the workers of the strange colony. The workers were fresh from their own natural home, and the queen had been in an artificial home for a month. As among ants the workers of different nests are usually hostile to each other, this adoption of an alien queen is an example of the strong instinct which controls for preservation of the species.

Ant-Intelligence.—A wonderful exhibition of ant-intelligence was witnessed by Mr. E. W. Cox, who gives in "Nature" an account of his observations. Two large cockroaches having been killed, their bodies were left lying on a gravel-strewed shelf in a hot-house; this shelf was four feet from the floor. In about twenty minutes a swarm of ants emerged from their nest, which was at some distance, climbed the wall, gained the shelf, and there, dividing into two parties, proceeded to take possession of the carcasses. The ants were the smallest of their kind; the body of their prey was nearly two inches long and half an inch in width. In order to carry these huge carcasses to their nest the ants had first to draw them for a space of ten inches over rough gravel, then along a smooth board for two feet, then to drop them to the floor beneath, then to drag them over some very rough rubble for sixteen inches, and finally to pass them between two slabs of wood into the nest. The author recounts as follows the difficulties encountered by one of the parties in removing the prey: They surrounded the corpse of the dead cockroach, and, seizing it with their mandibles, moved it onward a little way. It was inclined on its side, and when moved the projecting edges of the side hitched in the stones and prevented progress. On some larger stones near the spot were seen half a dozen ants looking at the work, but taking no part in it. When the hitch occurred, and whenever afterward any obstacle was met, these "surveyors" left their stations, went to the workers, and then returned to their place of observation. Forthwith the laborers changed

their plans. They now turned the cockroach on its back, and in this position they moved it onward triumphantly for three or four inches. At length the body was successfully brought to the smooth edge of the shelf, where it could be dropped to the floor beneath. But here occurred a new difficulty: the floor was strewed with bricks and plants. In fact, there was but one open space of about four inches square into which the body could be sent so as to be carried securely to its destination; to reach this spot they had to drag the burden along the ledge for a space of seventeen inches. That spot having been reached, the carcass was dropped by all at once loosing their hold of it. Previously to this, however, the "surveyors" had run down the wall to the floor and posted themselves directly under the ledge on which the body lay (four feet above). After the drop of the body, all the ants came running down the wall, seized their prey again, and in half an hour carried it a distance of nearly three feet to the entrance of the nest. But here a new difficulty faced them: it could not pass between the boards when lying on its back. They turned it on one side and tried again. At last, as the legs still hitched, the ants bit them off, and then the body was turned on its side and taken through the narrow way into the nest.

Cinchona Cultivation in California.—Five packages of fresh cinchona-seeds were received from India some months ago, by the Director of the Economic Garden of the University of California. These seeds represented five different species of cinchona, viz., *C. succirubra*, *C. calisaya*, *C. officinalis*, *C. condaminea*, and *C. hybrida*. Professor E. W. Hilgard writes in the "California Horticulturist" that the calisaya germinated most readily. At present there are growing in the propagating house of the Agricultural Department of the university several hundred healthy plants of each of the five species. So soon as the trees are sufficiently advanced they will be distributed to the various sections of the State of California, where the climate gives promise of success, there to be tried by careful and competent persons. The accounts received from India and Australia of the success of the cinchona in those countries, encourage the belief that some of the five species will prove hardy both as regards cold and drought in the coast region south of San Francisco, and in the more sheltered portions of the bay region. There the summer fogs and the uniformity of temperature seem to present the main conditions known to be requisite for the growth of the cinchona, which appears to be a tree of considerable adaptability.

Eastern Extension of the Long Island Drift.—Mr. Warren Upham, in an article on the formation of Cape Cod, published in the "American Naturalist," shows how the two series of drift-hills of Long Island extend, the more northerly one across Cape Cod from west to east, and the more southerly across Martha's Vineyard and Nantucket Island. The outmost border of the great ice-sheet of the glacial period is definitely marked by a continuous series of drift-hills which extend across New Jersey and from end to end of Long Island. From the Narrows to Montauk Point this moraine is commonly known as "the backbone of Long Island." The west portion, reaching from Fort Hamilton to Roslyn, is mainly an unstratified deposit; but from Roslyn to Montauk the hills are composed of modified drift. South of these hills are gently sloping plains of fine gravel and sand. Another series of plains extends to the north from Syosset to Riverhead, and thence continues along the north branch of the island to Orient Point. North of these plains, from Port Jefferson to Orient Point, is another series of drift-hills which, like the southerly chain, is mainly composed of stratified sand and gravel with few bowlders; but in the vicinity of Greenport and Orient the material is changed to a very coarse unstratified deposit like the upper till. This series is very plainly continued northeastward in Plum and Fisher's Islands, which are made up of hills of glacial drift like those near Greenport; thence it passes into Rhode Island at its southwest corner, and extends close to the coast seventeen miles from Watch Hill nearly to Point Judith. About two miles northwest from Point Judith it sinks to the sea-level, and its further continuation is lost, probably because it turns southward into the ocean.

Twelve miles to the south, the first or southerly range is lifted into view in Block Island. The sea covers the next thirty miles on the line of continuation of these two series of hills, but both emerge again, the northern forming the Elizabeth Islands and traversing the west-to-east portion of Cape Cod; while the southern moraine forms No-Man's-Land, the crest of Gay Head, and prominent ranges of hills in the northwestern part of Martha's Vineyard, extending northeast nearly to Vineyard Haven. Here it is lost, but it reappears on Chappaquiddick and Tucanuck Islands, and in Saul's Hills and Sankaly Head on Nantucket.

Professor Huxley on Bathybius.—In seconding the vote of thanks to Professor Allman at the close of his able address on protoplasm, delivered at the late meeting of the British Association, and elsewhere printed in this number, Professor Huxley alluded as follows to his past and present views regarding Bathybius: "It is my business to recollect, on the present occasion, that I have come to praise Cæsar, and not to bury him under any mountain of talk of my own; and I will, therefore, not venture to dwell upon any of those very large topics upon which he has dwelt with so much fairness, with so much judgment, and with so remarkable a knowledge of the existing information respecting them. But I will ask you to allow me to say one word rather on my own account, in order to prevent a misconception which, I think, might arise, and which I should regret if it did arise. I dare say that no one in this room, who has attained middle life, has been so fortunate as to reach that age without being obliged now and then to look back upon some acquaintance, or, it may be, intimate ally of his youth, who has not quite verified the promises of that youth. Nay, let us suppose he has done the very reverse, and has become a very questionable sort of character, and a person whose acquaintance does not seem quite so desirable as it was in those young days: his way and yours have separated; you have not heard much about him; but eminently trustworthy persons have assured you he has done this, that, or the other; and is more or less of a black sheep, in fact. The President, in the early part of his address, alluded to a certain thing—I hardly know whether I ought to call it thing or not—of which he gave you the name Bathybius, and he stated, with perfect justice, that I had brought that thing into notice; at any rate, indeed, I christened it, and I am, in a certain sense, its earliest friend. For some time after that interesting Bathybius was launched into the world, a number of admirable persons took the little thing by the hand, and made very much of it, and, as the President was good enough to tell you, I am glad to be able to repeat and verify all the statements, as a matter of fact, which I had ventured to make about it. And so things went on, and I thought my young friend Bathybius would turn out a credit to me. But, I am sorry to say, as time has gone on, he has not altogether verified the promise of his youth. In the first place, as the President told you, he could not be found when he was wanted; and, in the second place, when he was found, all sorts of things were said about him. Indeed, I regret to be obliged to tell you that some persons of severe minds went so far as to say that he was nothing but simply a gelatinous precipitate of slime, which had carried down organic matter. If that is so, I am very sorry for it, for, whoever else may have joined in this error, I am undoubtedly primarily responsible for it. But I do not know at this present time of my own knowledge how the matter stands. Nothing would please me more than to investigate the matter afresh in the way it ought to be investigated, but that would require a voyage of some time, and the investigation of this thing in its native haunts is a kind of work for which, for many years past, I have had no opportunity, and which I do not think I am very likely to enjoy again. Therefore my own judgment is in an absolute state of suspension about it. I can only warn you what has been said about this friend of mine, but I can not say whether what is said is justified or not. But I feel very happy about the matter. There is one thing about us men of science, and that is, no one who has the greatest prejudice against science can venture to say that we ever endeavor to conceal each other's mistakes. And, there-

fore, I rest in the most entire and complete confidence that, if this should happen to be a blunder of mine, some day or other it will be carefully exposed by somebody! But pray let me remind you, whether all this story about Bathybius be right or wrong makes not the smallest difference to the general argument of the remarkable address put before you to-night. All the statements your President has made are just as true, as profoundly true, as if this little, eccentric Bathybius did not exist at all. I congratulate you upon having had the opportunity of listening to an address so profound, so exhaustive in all respects, and so remarkable, and I ask you to join in the vote of thanks which has just been proposed."

A Specimen of African Civilization.—At the recent meeting of the British Association, Commander Cameron gave the following interesting particulars concerning the manners and customs of the people of Urua, a country in Central Africa bounded on the east by Lake Tanganyika, on the north by independent tribes in Manguema, on the west by Ulunda, and on the south by mountains south of Lake Bangucolo. The Uruans are probably the most civilized race in Central Africa. Their late supreme chief, Kasongo, claimed divine honors. On his death all his wives save one were slaughtered at the grave; the exempted wife passed to his successor, into whom also migrated the spirit of the dead Kasongo. The central object of the people's religious homage is an idol set up in the midst of a dense jungle; this idol has for wife one of the sisters of the reigning chief. Caste is very clearly defined. Authority is maintained by mutilation: hands, feet, ears, noses, are mutilated, and the people do not seem to mind it much. Fire is obtained by friction from a fire-block, and in one case a chief used the shin-bone of a conquered rebel to produce fire from the block! The dress of the people consists simply of an apron. The coiffure is curious. In some cases the hair is worked up into four ring plaits crossed at the top of the head like a crown, and surrounded at the bottom with a band of cowries or other shells. The people are not a hairy race, but they manage to grow their beards long and plaited like a Chinaman's pigtail. The women are tattooed. Commander Cameron saw a wedding, which was very curious. The festivities continued several days. A ring was formed of the natives, two men with big drums being in the middle. The drums were played and the people round danced. The bride was brought out, dressed in feathers and other finery, on the shoulders of two or three women; she was taken into the middle of the ring and was jumped up and down on the shoulders of the women. The bride threw shells and beads about, for which there was a scramble, as the possession of them was supposed to confer luck. Ultimately the husband came into the ring and putting the bride under his arm carried her off. The means of communication is by drum-signals. They have a call on the drum for everybody's name, and they can ask questions and convey intelligence over hundreds of miles and receive answers almost immediately. In war, messages are constantly sent enormous distances to bring up reënforcements or to stop their coming. The mass of the people live in huts on dry land, but there are one or two exceptions to this. Commander Cameron saw two lakes on which people were living in huts. In one case the people had covered over the long grass growing in the water with earth, and on that had built their huts; in the other the huts were built on piles.

NOTES.

Next year the American Association for the Advancement of Science will hold its meetings in Boston, commencing on the last Wednesday of August. The officers are: President, L. H. Morgan, of Rochester; Vice-President, Section A, Asaph Hall, of Washington; Vice-President, Section B, Alexander Agassiz, of Cambridge, Massachusetts; Permanent Secretary, F. W. Putnam, of Cambridge, Massachusetts; General Secretary, John K. Rees, of St. Louis; Secretary of Section A, Henry B. Nason, of Troy, New York; Secretary of Section B, C. V. Riley, of St. Louis; Treasurer, William S. Vaux, of Philadelphia.

The French Association for the Advancement of Science has just commenced the ninth year of its existence. From the beginning it has enjoyed the largest measure of prosperity, and its meetings in sun-

dry provincial towns and cities have been numerously attended by the leaders of science and the educated public. Financially the Association stands upon a very satisfactory basis; its capital amounts to about sixty-five thousand dollars, and it is rapidly growing.

It is the opinion of Professor A. R. Grote, expressed at the recent meeting of the Entomological Club at Saratoga, that the damage done by the employment of Paris-green is greater than that done by the potato-bug. This conclusion Professor Grote has reached after a careful study of the effects of Paris-green agriculturally employed. He has found cases of the poisoning, by this agent, of horses, cattle, sheep, poultry, and even human beings.

Mr. S. H. Scudder's "Catalogue of Scientific Works" is now completed, and has been printed by the directors of the Harvard University Library. It is a book of three hundred pages, and fifty pages of index. The entries in this catalogue represent over seventy thousand volumes.

In the sub-Section of Anthropology, at the late meeting of the American Association for the Advancement of Science, Mr. Albert S. Bickmore, Director of the Central Park Museum of Natural History, exhibited a large and most interesting map, which showed the distribution of the races of man in the islands of the Indian Ocean and the Pacific. By means of arrows were indicated the routes the different peoples appear to have taken in reaching their present abodes.

Is is stated in the "Nord Deutsche Zeitung" that a woman in the neighborhood of Düsseldorf, who had been bitten by a mad dog, was cured by hypodermic injections of twenty centigrammes of curari.

During an outbreak of scarlatina at Grantham, a town of Lincolnshire, England, nine tent-hospitals were set up in a field just outside the town. These tents were all lined, and had raised wooden floors, which were trenched round. A wooden building was erected to serve for wash-house, kitchen, dispensary, etc. A separate structure was put up for earth-closets. No provision was made for warming the tents, the season being mild. Patients were admitted on June 30th, and the tents were occupied during the eleven weeks following. Sixty-six patients, varying in age from eighteen months to thirty-eight years, were treated; six of the cases ended fatally.

The great question of the day for physicians to study, says Dr. S. D. Gross, of Baltimore, is preventive medicine, the hygiene of our persons, our dwellings, our streets; in a word, our surroundings, whether in city, town, hamlet, or country; and the establishment of efficient town and State boards of health, through whose agency we shall be better able to prevent the origin and fatal effects of what are known as the zymotic diseases.

Died at Cape Town, July 14th, Sir Thomas Maclear, Director of the Royal Observatory at that place for nearly forty years down to 1870, when he retired. His principal work was the remeasurement of Lacaille's arc of the meridian, the results of which were published in 1866.

Mr. Keith Johnston, son of the eminent geographer, Alexander Keith Johnston, and himself distinguished as a geographer and explorer, died of dysentery on June 28th, at Berobero, a place about one hundred and fifty miles southwest of Dar-es-Salaam. At the time of his death he was engaged in making an exploration of Africa, under the auspices of the Royal Geographical Society of Great Britain.

Among 3,050 colored children in the schools of the District of Columbia, of whom 1,359 were males, and 1,691 females, Dr. Swan M. Burnett found twenty-four individuals affected with color-blindness, viz., twenty-two boys (1·6 per cent.), and two girls (0·11 per cent.). This proportion of color blindness is very low; among whites it is three per cent. for males, and 0·26 for females.

A person in England having purchased a ring set with what purported to be a *diamond*, and having later discovered that the stone was a "Cape diamond," entered suit at law to recover the money paid for the ring. Judgment was given for the plaintiff on the evidence of several diamond-dealers, who testified that "Cape diamonds" are *not to be regarded as ordinary diamonds*, and that they lack the essential qualities of the Brazilian stones, viz., luster, hardness, and color. A writer in "Nature" calls attention to this singular verdict, and expresses the hope that, when the case comes up for a retrial, the judge will require some *scientific* evidence (such as specific gravity or chemical composition) about Cape diamonds.

Sixteen thousand panes of glass were recently smashed in the plant-houses of the Royal Gardens at Kew, during a violent hailstorm, that lasted scarcely ten minutes. The hailstones averaged one and a half inch in diameter, and weighed about three-fourths of an ounce apiece. In most cases the panes of glass were completely shattered, but some were found pierced with perfectly circular holes, as if a bullet had been shot through them. The succulent leaves of a few of the plants were penetrated in a similar way.

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